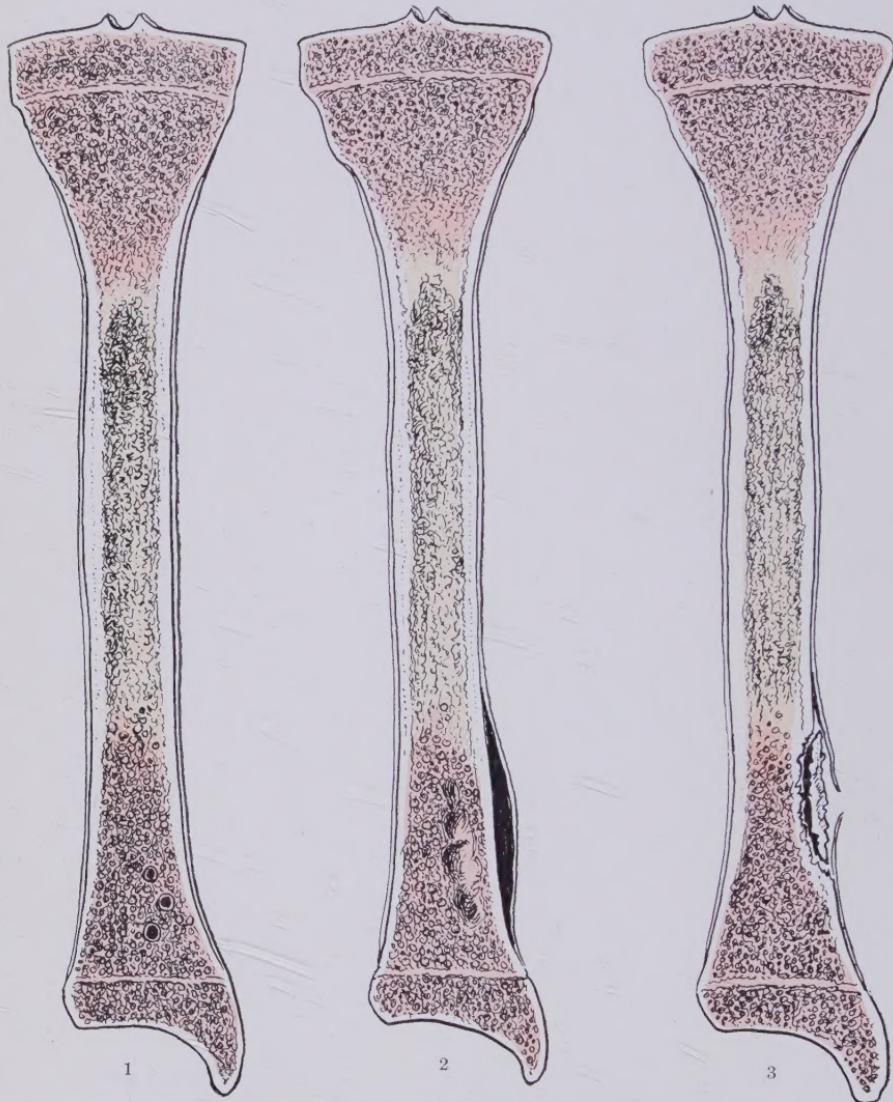FIG. 1.—Diagram of very early stage of acute osteomyelitis: Bacterial emboli have lodged in the red marrow of the lower metaphysis. Trephining or drilling the overlying cortex is indicated.

FIG. 2.—The bacterial infection of the metaphysis has spread in the red marrow, and there is a seropurulent effusion beneath the periosteum. Drainage of this, without also opening the cortex, is not sufficient.

FIG. 3.—In favorable cases the acute disease subsides but a cortical lesion will form, with or without operation.
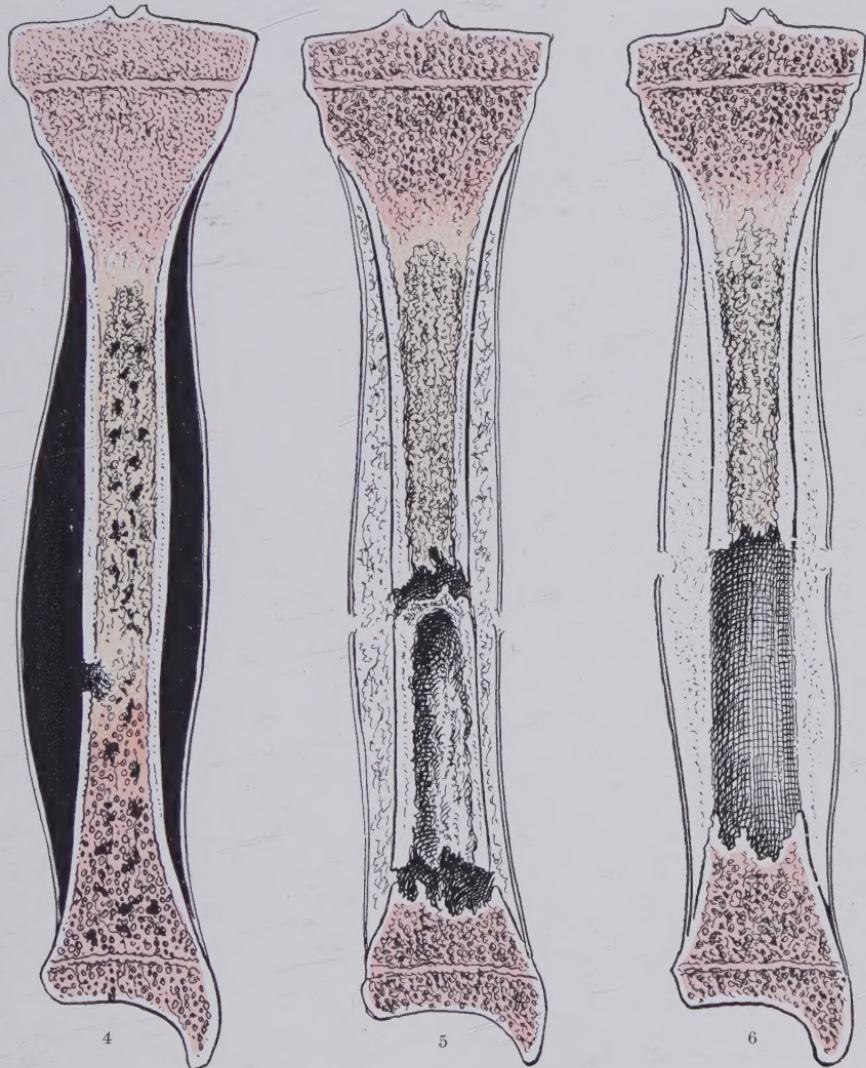
Fig. 4.—This stage follows that shown in Fig. 2, unless infection is mild or early adequate drainage of marrow is provided. Note purulent infiltration spreading throughout shaft; periosteum widely detached by pus; and macroscopic perforation of cortex (*cloaca*).

Fig. 5.—The formation of a tubular *sequestrum* is frequent if the disease advances to stage shown in Fig. 4. Note in Fig. 5 the tubular sequestrum and adjacent cortex are enveloped by still plastic subperiosteal bone (*involucrum*).

Fig. 6.—Unless the sequestrum is removed while the involucrum is still plastic, the resulting cavity will never be obliterated spontaneously. Its sclerosed walls are no longer capable of osteogenesis.

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TO STUDENTS AND PRACTITIONERS

BY LEADING MEMBERS OF THE MEDICAL PROFESSION
THROUGHOUT THE WORLD

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Symposium on Physiotherapy

A NEW PHYSIOTHERAPY TECHNIC FOR SOME INTRANASAL DISEASES *

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DEVELOPMENT of a relatively new technic for physical measures in successful treatment of intranasal pathology is the basis of this article. The efficacy of physiotherapeutics in these affections rested originally upon empirical grounds, as had been the case with practically all physical forms of accepted therapy. Exactness in treatment was brought about by the growing perfection of physical apparatus with a corresponding gain in the knowledge of its scientific application—along with increased diagnostic accuracy and development of systematized technic.

It was found that positive benefit can be derived in severe acute and in more or less resistant chronic pathologic and symptomatic conditions of the nasal tract, its accessory sinuses included.

In the clinical service in which the following methods were evolved, all cases were referred from the special nose and throat clinic, where thorough examination and diagnosis are invariably made by a specialist; checking up of final results by the latter, after physiotherapy, is also the rule. On admission of the patient to the Physiotherapy Clinic, the accompanying full report of clinical findings is reviewed by the physician in charge of physiotherapy, these findings including those by X-rays and by reports of smears and culture growths. Before prescribing treatment a complete description is made of all clinical findings and subjective symptoms, these being accurately detailed in the case record. Upon completion of this record a prescription of physical treatment is outlined.

The following cases have been treated with notable success:

ACUTE INFECTIONS

In treatment of acute affections of the nasal mucosa and accessory sinus the following chain of symptoms is usually met with: Sudden onset of profuse hydrorrhœa, rhinorrhœa, irritating cough, headache, chilliness with general malaise and, sometimes, sore throat and slight fever. This type of patient, when seen during the first twenty-four hours of the contagion or earlier, is usually not sick enough to be hospitalized or put to bed but presents symptoms that warrant intensive abortive treatment. The following modalities are applied in sequence: Vibration is made with a double prong vibratode for three minutes over the interspace between the seventh cervical and first dorsal vertebræ (Fig. 1). The procedure to be effective is applied in the following manner: The patient is seated facing the back of a chair, his head and neck bent sharply forward, resting upon the folded arms, at the same time relaxing the muscles as much as possible. The interspace is carefully located and the vibratode applied with fairly firm pressure for from three to five minutes. This application produces a reflex impulse, the anatomic route of which was first called to our attention by Dr. A. P. Brubaker [2] (Fig. 2). It can be traced from the inflamed nasal tract by way of the nasal ganglion, the vidian nerve, the carotid plexus to the sympathetic trunk between the seventh cervical and the first dorsal vertebræ, known as the stellate plexus. This reflex effect gives almost instant relief from the aggravating congestion and irritation and diminishes the profuse hydror-

Fig. 1.

Application of two-prong vibratode between the seventh cervical and first dorsal interspaces for relief of acute coryza.

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FIG. 1.

Application of two-prong vibratode between the seventh cervical and first dorsal inter-
spaces for relief of acute coryza.

Fig. 3.

Application of radiant light by deep-therapy lamp.

rhœa with a definite subsidence of all coryzal symptoms. This application of the electrical vibrator, repeated several times during the first twenty-four hours, may alone suffice to abort the so-called acute " cold in the head " ; more often, several days of such application are needed.

Additional treatment may, however, be found necessary for acute affections, existing twenty-four hours or longer, such as acute nasal

FIG. 2.

5ᵗʰ nerve

Great petrosal nerve

Facial nerve

Spheno-palatine ganglion

Nerve of Wrisberg

Sup. cervical ganglion

Sympathetic cord

Secreto-motor center

Vaso-dilatator center

Vaso-constrictor center

Cutaneous nerves
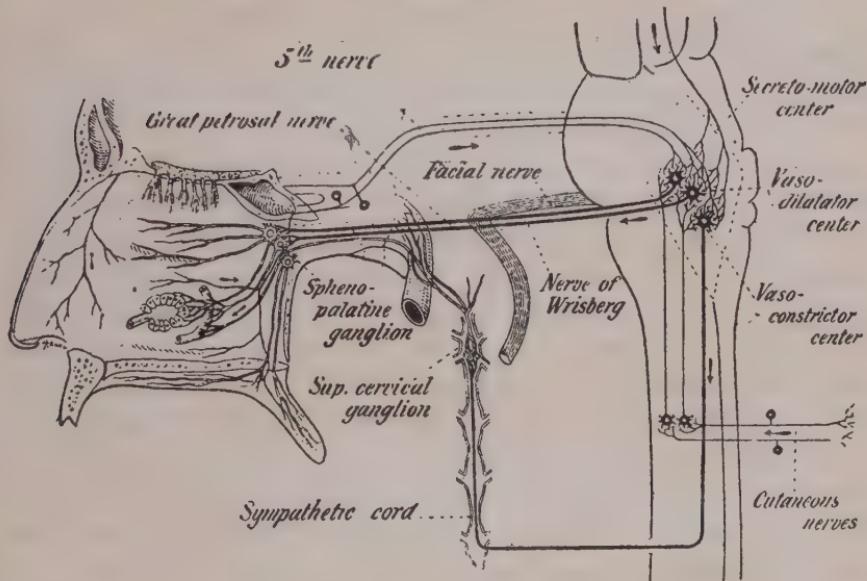
Diagram showing the nerve mechanism concerned in the innervation of the nasal chambers. (Courtesy of Dr. A. P. Brubaker.)

catarrh, coryza, acute rhinitis, acute nasopharyngitis, and acute frontal, sphenoidal and maxillary sinusitis with or without a serosanguinous or mucopurulent discharge and with accompanying headache and neuralgic pains of varying intensity. For some of these conditions, particularly the more acute, vibration is given as described above; in others it is omitted and the following modalities used in sequence: Radiant light (as differentiated from heat), from a standard radiovitant applicator carrying a 1000- or 1500-watt daylight-blue bulb that filters out the long heat rays, is directed over the face for twenty to thirty minutes or longer (Fig. 3). During this application each eye is protected by a moist pack of absorbent cotton, each

pack covered by a layer of black paper. The cotton and paper should fit snugly over the orbital region leaving only the bridge of the nose and as much of the supra- and infra-orbital regions exposed as is practical. By inducing a deep hyperæmia this application relieves the sense of fulness and congestion about the nasal mucosa and sinus openings, enhances local nutrition and thus soothes the pain, promoting comfort.

The production of heat within the tissues by the penetration of radiant light was originally called to our attention by such pioneers as Cleaves,[3] Snow,[4] Thompson,[5] and Kinney.[6] Thermotherapy (*radiant light or radiant energy*) has a distinctive and selective action on the tissues exposed. The uniform temperature, due to penetration of soft structures by the light rays when given over sufficiently long periods, produces an active hyperæmia. The duration and repetition of exposures depends on the severity of symptoms and on the existing pathology. This application gives at once a definite amelioration of symptoms. The production of an active hyperæmia by *conversive* heat is likewise of paramount importance because it renders an inadequate inflammatory or pathological condition into an adequate physiologic condition in the tissues irradiated. To understand the action of reflected light, one must remember the old law in physics of the conservation of energy and realize that, when light energy is arrested, heat is generated. Holding in mind this phenomenon, we know that reflected light penetrates the tissues and generates heat within according to the degree of resistance of the part. This effect has been proved clinically to be far more beneficial than the application of heat from without by such local applications as a mustard plaster, poultices, hot-water bottles, etc. It is important in this connection to recognize the following confirmatory experimental work of Dr. Virgil C. Kinney [6] on the penetration of light rays, the result of extensive research and scientific tests :

(1) Natural sunlight has a greater depth of penetration, as far as experiments indicate, than any known artificial form of radiant energy with the exception of radium and the X-rays. (2) Fluoroscopic or ocular tests show that light—the visible spectrum—will penetrate living animal tissues in great quantity from one-half inch or less up to one and one-eighth inches. An opaque body, passed

between the light and the exposed part, produces a distinct shadow. From one and one-eighth inches up to one and three-eighth inches light comes through in a far less degree; it is so faint that, when an opaque body is moved between the exposed surfaces, the light does not produce a shadow. Between one and three-eighth inches and one and seven-sixteenths inches is an area admitting some light but so much less in degree that it may be left out of calculation. At one and one-half inches practically all light is absorbed in transit and, no matter how long the observation is carried on, nothing but darkness is encountered. These same results have been obtained by means of very rapid partly achromatic photographic plates. Thus one and one-half inches of animal tissue is the greatest possible depth through which light will pass. (3) A pigmented skin offers no more resistance to the penetration of light rays than does a perfectly white skin when observed fluoroscopically or ocularly, while a photographic plate which theoretically is more sensitive to light rays than the human eye goes a step farther and shows that pigmented skin transmits light better than an unpigmented one. This Kinney has repeatedly demonstrated by means of experiments with blonds, brunettes and negroes. This he attributes to the fact that the pigment in a tanned skin, of a natural brunette, or a negro, which is brown, on exposure to light, reacts as a yellow color, and yellow transmits light better than any other color. (4) The pigment which collects within the skin, because of contact with the ultra-violet portions of the sun's rays, acts to increase the resistance against the burning and blistering effects of those rays. Mucous membranes pigment but little if any, and so do not toughen and therefore are very prone to burning, cracking open and to ulceration. The human skin, if allowed to pigment, toughens and then will resist not only the irritating action of the sunlight, but also of strong winds and, to a great degree, of the X-ray.

Clinical experience shows that the effects of radiant light and heat energy are traceable to the positive physiologic reactions obtained when applied to the facial regions. The routine advised included these modalities: Radiant light and heat is immediately followed by an intranasal high-frequency application given with a non-vacuum electrode, insulated preferred, and attached to the Oudin terminal of a dependable high-frequency machine. Always test out the elec-

trode before its insertion into the nasal chambers, by turning on the current and placing the electrode against the operator's face or hand until the soothing warmth is felt, the dosage for a sedative treatment. For the first part of the treatment, insert the electrode gently into each nasal fossa, as far back as possible, for five minutes to each side. During the five minutes' application gently change the position of the electrode by bringing it forward slowly in order to cover the entire nasal mucosa. For the second part of the application, test the electrode as before by turning on the current until a slight effluve or a fine sparkling effect is shown which is stimulating. Then repeat the same procedure as used in the sedative application, slowly drawing the electrode forward. Duration of treatments can be gradually stepped up from five minutes, sedative and stimulative, to each side of the nose, to applications of double that period. The sedative variety produces a superficial hyperæmia of the local inflammatory process, on the exact control of which depends the relief of symptoms. The stimulative variety decongests the swollen and congested turbinates and nasal mucosa.

In definitely localized sinus involvement the non-vacuum electrode is directed toward the sinus exit, concentrating the current as near the involved spot as possible. Selection of a rounded or thin flat electrode can be made as indicated (Figs. 4 and 5). All applications are guided by tolerance of the patients, some taking more current than others.

This is followed by intranasal use of ultra-violet rays given with a Muehler nasal quartz applicator attached to a water-cooled lamp (Fig. 6). The applicator at first is inserted gently as far back into the nasal cavity as possible, then is withdrawn slowly to permit of fractional irradiation to the entire mucosa. The applicator should not be pressed heavily or faced against the nasal membrane but allowed to lie gently upon the affected parts. In sinus disease the applicator is inserted so that the tip approaches the affected sinus opening as nearly as possible. The author has designed a special curved quartz applicator to accomplish this procedure and has found it particularly beneficial in directing the ray into the fossa of Rosenmüller which is often the site of infection (Fig. 7). In using the straight flat Muehler quartz applicator the tip can be directed upward or down-

Fig. 4.
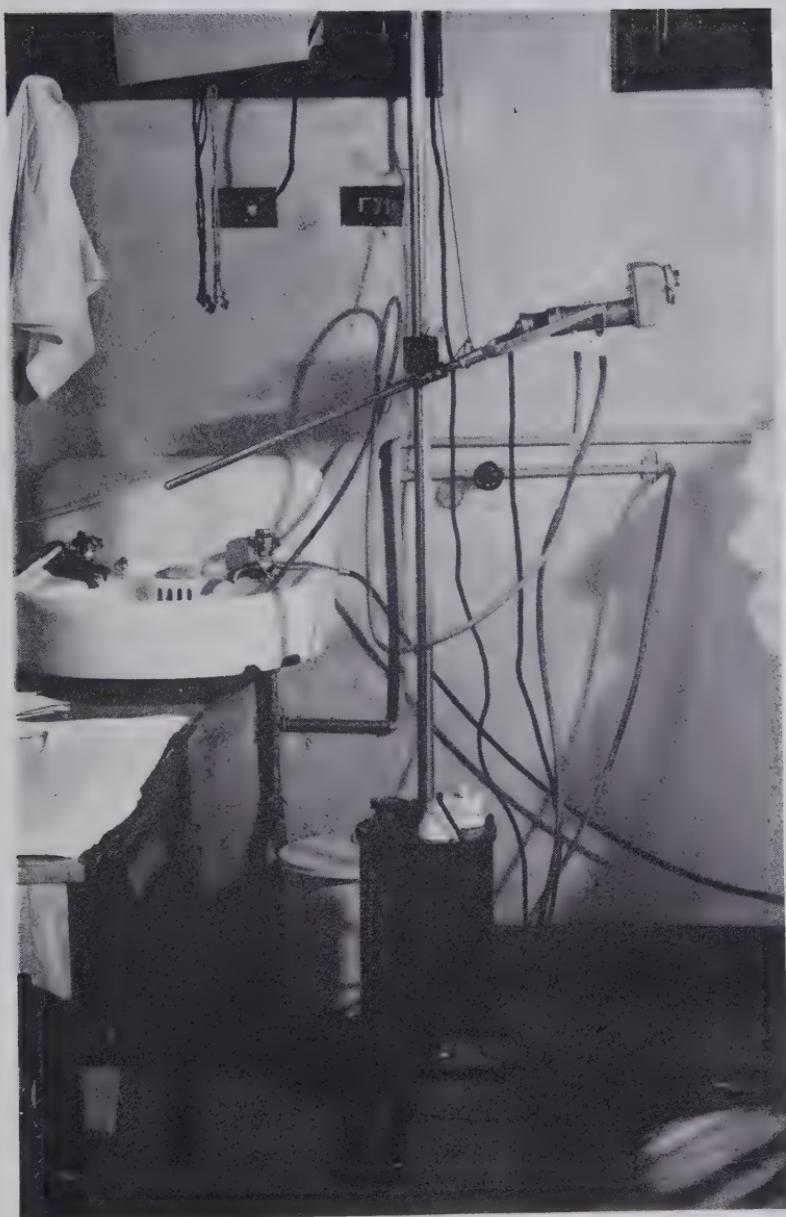
Water-cooled, ultra-violet ray lamp, fully connected, with quartz applicator attached.

ward as indicated. Duration of treatment at first lasts one minute to each nasal fossa; fractional irradiation, about fifteen seconds; this is increased one-half minute each subsequent treatment up to five minutes or longer, fractionally applied. It must be remembered, in this connection, that most of the ray is emitted at the tip of the applicator, only stray rays bounding from the sides. Treatments should be accurately timed to avoid blistering, a contingency not particularly harmful but also not desirable.

Following the exposure to both anterior cavities, the posterior nares and nasopharynx are thoroughly rayed. The Sampson [7] hay fever quartz applicator is designed for this especial purpose, permitting a general irradiation to these regions. This effort may start

Fig. 7.

Brooke double curve quartz applicator.

coughing or gagging by the patient, to be obviated by applying a solution of novocaine or cocaine about the uvular and nasopharyngeal wall.

Where there has been an extension or complicating infection of the throat about the tonsillar and peritonsillar regions, these should be rayed, using the Baldwin or Plank quartz applicators. Duration of treatment to the nasopharynx and posterior nares is about one-half minute at the outset, increasing one-half minute each subsequent treatment. Exposures to the throat are given for the same periods, all treatments being accurately timed with the interval time clocks. All cases not complicated by acute sinusitis are improved after an average of three treatments and altogether relieved after five or six applications, as outlined in the above-described sequence.

Action of Actinic Rays.—Since ultra-violet or actinic rays play an important rôle in the treatment of nasal and oral conditions, the following information is given to better understand their action and reaction when applied to the tissues: There are two types of lamps supplying ultra-violet rays, air-cooled and water-cooled, and both

produce ultra-violet irradiations from quartz mercury vapor burners. It must be realized, however, that their construction and therapeutic actions are quite different. Pacini [8] shows that the air-cooled lamp (Fig. 8) emits the longer light waves between 3920 and 3000 Ångström units; the water-cooled lamp, the short light wave-lengths, between 3000 and 2000 Ångström units. The rays of long wave-length emitted from the air-cooled lamp are more penetrating than the rays of shorter wave-length. They produce an erythema solare or sunburn more quickly and with greater intensity. They are dominantly biological, chemically oxidizing, relatively penetrating and a metabolic synergist. The shorter wave-lengths from the water-cooled lamp differ in being dominantly bactericidal, chemically reducing, relatively superficial and a metabolic depressor.

The ultra-violet rays from an air-cooled lamp are readily absorbed into the capillary blood-stream and carried to all parts of the body; they stimulate the phagocytic action of the leucocytes with increased formation of antibodies, and raise the quantity and quality of the red blood-cells. When the physical resistance of the host is inadequate, it is always my practice to employ the general body tonic ultra-violet irradiations from an air-cooled lamp in addition to the local intranasal and oral applications from a water-cooled lamp. The general absorption of the ultra-violet rays into the body does much to rejuvenate tissue and thus indirectly eradicate disease conditions. The ultra-violet rays from both lamps are bactericidal, the rays from the water-cooled lamp being much more so, thereby destroying all forms of pathological organisms with a greater degree of certainty. It must be remembered that ultra-violet rays will not pass through ordinary glass, the pure fused quartz applicators being the only available conductors of ultra-violet energy. It is of importance to exercise extreme care in giving ultra-violet irradiations for they readily cause a burn of the skin and blister the mucous membranes. This fact, as just stated, is not particularly harmful but is not desirable unless a destructive action is indicated. This accident can be avoided by careful standardization of the lamps for the initial treatment and then proceed by gradually increasing the time of exposure and in case of the air-cooled lamp varying the distance from the part. A lamp is standardized by finding out the distance from the part and the time

required to produce a mild erythema solare or sunburn. The lamps should be permitted to burn for at least five minutes in order to reach maximum efficiency before treatments are given. The reaction depends on the type and intensity of your burner and the duration of the exposure.

Some European practitioners favor the arc lamp as furnishing a greater volume of ultra-violet rays than does the quartz burner, the latter having far wider use in cisatlantic countries. The rapid wastage of the rods in the arc instrument on passage of the current, however, is a factor that would prejudice many physicians against its employment as compared with the more convenient quartz lamp.

The following examples illustrate the possibilities of the above-described technic:

A case worthy of mention, A. H., was admitted to the clinic August 9, 1923, with acute rhinitis, acute follicular tonsillitis with beginning peritonsillar abscess. After receiving two treatments, prompt relief was obtained and the peritonsillar abscess aborted. To make sure of avoiding the recurrence, two additional daily treatments were given and the patient was discharged as " maximum improved."

A case of acute ethmoidal sinusitis, T. M., admitted February 30, 1923, for localized pain and generalized neuralgia, with a serosanguinous discharge, was promptly and adequately relieved after ten daily treatments.

A case of pansinusitis, D. B., admitted to the clinic November 27, 1922, received fifteen treatments, after which he was entirely relieved. The first six treatments were given daily; then visits were lessened to alternate days.

During the course of these treatments patients usually remain at their work in comfort. The progress in all cases is uniform and ultimately beneficial. The length of time to obtain maximum improvement varies in accordance with the individual case, duration of infection, its severity, extent of involvement and the bodily resistance of the host. Treatments should be given at first twice a day, gradually reducing them to daily and then to more infrequent applications as symptoms require.

HAY FEVER

Hay fever (rhinitis hyperæsthetica) is now regarded as a reaction of anaphylactic nature in sensitized persons; in others, it is a reflex neurosis.[9] The primary factor in hay fever still remains a mooted question; certain protein pollens with the presence of bacteria and the element of neurosis are, however, factors to be considered.

This condition is characterized by marked swelling and congestion of the nasal mucous membranes, profuse hydrorrhœa, aggravating irritation, sneezing, fulness in head that causes difficult breathing, husky voice, general langour and restlessness. The conjunctiva becomes inflamed, smarts, itches and emits a copious discharge. The application of radiant light, intranasal high-frequency current and the ultra-violet ray to the anterior and posterior nares, nasopharynx and throat, in sequence, as outlined under acute nasal conditions, always gives prompt and efficient relief. Treatments, if started sufficiently early before the expected time of attack, will shorten, favorably modify and often abort the distressing symptoms. When treated during an attack the therapeutic value is marked, always giving prompt, efficient and adequate relief. The technic as outlined under the treatment of acute nasal and sinus disease is used, but the intranasal high-frequency electrode and the ultra-violet rays are given more intensively, more often and for a longer duration per visit. It has been observed that the prophylactic and the therapeutic values of the treatment outlined, particularly in conjunction with administration of suitable pollen and other immunization extracts, are certainly beneficial. To assure the advantage of pre-seasonal treatment, the above-cited modalities should be started prior to the time for onset of symptoms to assure best results. When this is not possible, the less desirable though always beneficial co-seasonal treatments are resorted to as outlined.

The diagnostic sensitization tests are, however, of particular importance in these cases, especially when symptoms are accentuated during the pollinating seasons. It is recognized that specific treatment is essential when diagnostic tests are positive. Two cases worthy of mention were relieved after receiving three treatments; one was treated during the attack and the other at the beginning; in the latter instance symptoms became so mild that it was difficult to have the patient report for additional treatments, one application giving him adequate relief.

CHRONIC INTRANASAL INFECTIONS

Treatment of the various chronic infections, including post-operative nasal and sinus conditions often met with, is much more prolonged than for the acute varieties. The symptoms usually present

FIG. 8.

Body application of ultra-violet ray air-cooled lamp.

Fig. 9.

Modified diathermy by means of inactive, triangular, metallic electrode in position, an active non-vacuum electrode being applied for relief of frontal sinusitis.

FIG. 10.

Modified diathermy inactive metal electrode secured by adhesive plaster, and active non-vacuum electrode applied for relief of antritis.

FIG. 11.

Modified diathermy-binocular non-vacuum electrode *in situ:* Applied for relief of orbital neuralgia in frontal and ethmoidal sinusitis.

are hypertrophy with induration, swelling and congestion or a shrunken, crusty condition of the nasal mucous membranes and sinus apertures. Together with a profuse mucopurulent discharge, neuralgia of varying intensity, with localized tenderness, and pain of a deep and boring character are felt over the affected sinus regions. Acute exacerbations are often superimposed on the existing chronic condition, the usual aggravating acute symptoms being present. Post-operative cases present considerable cicatricial tissue and hyperplasia greatly interfering with the normal function of the nasal membranes and sinus openings. Such cases have usually been submitted to repeated surgical operations and sinus punctures, the symptoms varying and being marked by alternate periods of acute exacerbation and quiescence.

The following types of conditions have been treated successfully and will be considered collectively: Hypertrophic rhinitis, atrophic rhinitis, chronic ethmoiditis, chronic frontal sinusitis, chronic antritis, and chronic post-operative nasal and sinus conditions. The technic used in these conditions includes modified diathermy, which the writer has used with notable success, followed by the intranasal high-frequency current and ultra-violet rays.

MODIFIED DIATHERMY

Application of modified diathermy is made in this sequence: A dispersive inactive triangular-shaped electrode is used, made of 22-gauge Crookes' metal (50 per cent. each of lead and tin), measuring three by four inches (Figs. 9 and 10). The tin prevents marking of the skin by the lead. This electrode is well-soaped and applied to the upper cervical and occipital regions, which area should likewise be soaped; the apex fits well up to and slightly over the occipital prominence, the operator being careful to shape and mold the metal to the part to insure perfect contact. It is then bandaged firmly to the part, a rubber elastic bandage being preferable, to secure coaptation. The connection is made by means of a Fahnestock clip and its rheophore, to one of the d'Arsonval binding posts. The active electrode is a non-vacuum electrode, the size of which ranges from one-quarter inch to one and one-quarter inches in diameter, depending on the regions to be treated, connected to the other d'Arsonval binding post. This constitutes the first step of the application. The

next one is carried out by throwing off the current and changing the connection of the active electrode from the d'Arsonval binding post to the Oudin terminal; the connection of the inactive electrode remains the same, thus giving a combined d'Arsonval and Oudin current. The position of the patient may be either sitting or lying; the latter is preferable as it permits complete relaxation, a pillow having been placed under the knees. The operator sits on a stool applying the active non-vacuum electrode to the affected areas with his right hand, the left being free to operate the machine. During the first step a general application is given to the entire surface about the nasal and all sinus regions—the electrode, in motion, concentrating as much as possible over painful sinuses and the area of distribution of neuralgic pains. Duration of this application is about fifteen minutes, the patient usually tolerating from 100 to 200 milliamperes of current with comfort. Concentration may be made over certain painful regions for from one-half to one minute, in some cases longer, with marked relief. The second step permits of a fractional application, using a non-vacuum electrode that varies in size according to the affected regions; the operator thus concentrates the electrode for two or three minutes over each affected sinus region with a current ranging between 50 and 100 milliamperes. When a small electrode measuring less than one-half inch in diameter is used, it is connected to the Oudin terminal, the inactive metal electrode being disconnected. This permits more penetration with less heat-effect and is particularly beneficial in treatment over the ethmoidal and sphenoidal regions. The non-vacuum double-eye electrode (Fig. 11) is applied in the same way to the closed eyes including the margins of the supra- and infra-orbital fossæ. This application not only relieves the radiating pains about either orbital regions but also lessens the congestion and inflammation of the conjunctiva which often accompanies sinus affections. Such an application occupies a period not usually exceeding fifteen minutes, the combined treatment requiring not more than about thirty minutes.

Certain precautions are always to be observed: The face and forehead of the patient should be dusted with talcum powder to prevent irritation of the skin before applying the active non-vacuum electrodes. These applications should be given carefully, stepping

the current up very gradually in each case, the dosage regulated by the tolerance of the patient, some being able to tolerate more current than others. Do not push the maximum intensity of the current to extreme tolerance as better effects can be gained through a dependably uniform degree of heat by only a moderate intensification of current to a comfortable tolerance of the patient. This being done by applying the active non-vacuum electrode directly up over the distribution of nerve manifestations.

DIRECT DIATHERMY

The use of direct diathermy (d'Arsonval current) is a dependable resource in uncomplicated sinus affections. The disadvantage in direct diathermy is that the metal electrodes must remain stationary, the smaller active electrode being placed over the area affected, the inactive over the occipital (or, rarely, parietal) region of the scalp. The electrical force flows in straight lines between the electrodes, concentrating always nearer the smaller active electrode; the smaller the electrode, the nearer the concentration of current beneath this active electrode. This would permit of a very small area being treated with a minimal degree of heat intensity, whereas the use of larger electrodes with a current sufficiently strong to produce the desired effects would cause too great a flow of current through the brain along the path between the electrodes. This application has infrequently produced congestion and consequent fulness in the head with complaint of headache, depression and dizziness by the patient. The *direct* method of application is used by the author in some cases where the infection is definitely localized and confined to the antrum of Highmore. In a number of cases of antritis this technic has proved successful; best results, however, have been obtained at this site by following the direct application of diathermy by modified diathermy with a duration of fifteen minutes for each application. The unipolar Oudin current is often found too superficial in its action here; it can, however, be used, a very small non-vacuum electrode employed, and is indicated in making direct applications to the ethmoidal, sphenoidal and other sinus regions (Fig. 12). In these cases the Oudin current, as above described, is used with modified and combined diathermy currents. The use of the combined d'Arsonval

and Oudin currents is far preferable when an electrode of a little larger surface dimension is required as, for example, the double-eye non-vacuum electrode, or the sizes here illustrated. When the medium-sized electrode can be used the modified d'Arsonval current will be found more effective, producing a greater concentration of heat over a larger affected area, as in antritis and frontal sinusitis with radiating neuralgic pains. Applications are repeated daily first and then gradually reduced in frequency as symptoms indicate.

The conjoint applications here described have proved to be the most effective and are far better than the direct diathermy or the typical Oudin high-frequency currents. The modified diathermy and the combined d'Arsonval and Oudin high-frequency currents have likewise been found to be more efficacious than the reflected light in severe, acute and chronic pansinusitis with much pain and in acute apparently localized sinus diseases with severe pain, much congestion and discharge. (Fig. 13.)

The advantages of the use of modified and combined diathermy and Oudin currents over direct diathermy application, where two pieces of metal are used with the smaller one over the affected area and the larger one opposite, are thus explained: In modified and combined diathermy a mild current is dispersed from the metallic inactive electrode, the lines of electrical force converging to the active non-vacuum electrode placed directly over region affected, and, on meeting the diverging lines of electrical force just beneath the smaller active non-vacuum electrode, this concentrates the maximum intensity of electrical energy with formation of greatest heat in the particular area involved. When the active non-vacuum electrode is moved from one area to another the lines of electrical concentration follow with the same effect just as where the electrode is stationary. In this way all affected areas of face and head come within the range of application, permitting concentration at any point and at any time desired. This application permits control of the neuralgic pains radiating along the intricate nerve ramifications.

The effects of diathermy, as we know, are derived not only from the passage of a current of relatively high amperage and relatively lowered voltage through given tissues but as well from the bombard-

Fig. 12.

Modified diathermy, showing small non-vacuum electrode held stationary over ethmoid region.

FIG. 13.
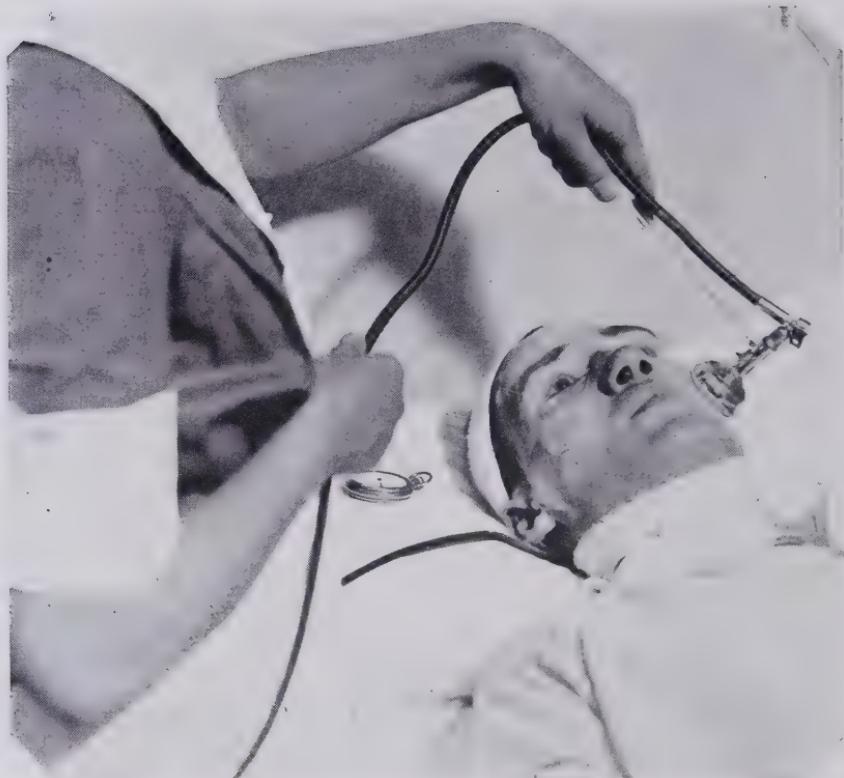
Modified diathermy, showing large movable non-vacuum electrode, complete connection, and the method of handling the instrument by the operator.

ment effect of the excessive frequency and the amplitude of the oscillations set up in the given tissues by the rapidly moving electrons. The heat is due to the friction produced both by the oscillatory action of the current and the strength of the current passed into the tissues. The physical effects of diathermy are local vasodilation, a deep hyperæmia, locally confined penetration of heat, antispasmodic action, a marked sedation, increased local metabolism and nutrition of tissues and accelerated removal of waste products.

INTRANASAL HIGH-FREQUENCY APPLICATIONS

Modified diathermy application is to be followed by intranasal high-frequency Oudin current and ultra-violet ray in all severe acute and chronic affections. The technic is the same as outlined for acute affections except that in degree it is more intensive, the initial applications being twice as long, though not repeated as often as for acute infections. The intranasal high-frequency currents, given for at least ten minutes to each nasal fossa, thoroughly heat and vascularize the hypertrophied and bound-down constricted nasal membranes, thus gradually restoring a normal action of the devitalized nasal mucosa. The intranasal ultra-violet ray is given more intensively at first—for two to three minutes, fractionally applied—for a destructive action on the tissues as well as for the desired antiseptic action. For destructive action the application is given up to the point of vesication, thus destroying all fibrous, hypertrophied and cicatricial adhesions. It slowly stimulates normal tissue activity but this outcome necessitates prolonged, frequent attendance of patients before maximum improvement can be obtained. In debilitated patients the general body ultra-violet irradiation is indicated for tonic effect, having been proved beneficial to stimulate metabolism. It is important to remove all discharge and secretions from nasal fossæ before giving the intranasal applications. In the treatment of all nasal and sinus diseases it has been found that certain assistive measures, utilized in the nose and throat clinic, notably the mechanical suction of sinuses preceding physiotherapy applications, are helpful and hasten removal of the disease. The duration and repetition of treatments depend on the extent and intensity of infection, and on other factors of the case.

The insulated vacuum nasal electrode inserted into the nasal chambers for ten minutes and connected up from the wave current to a static machine, with the ground chain off, has been found to reduce the swollen and congested turbinates.

The following are typical instances illustrating the procedures here described:

Patient H., reported in the morning for treatment of a severe acute left antritis, causing localized and radiating pain with mucosanguinous discharge, which prevented sleep the night before. Thirty minutes' application of modified diathermy was made at once over the left antrum and adjacent parts, this being followed by left intranasal high-frequency current and ultra-violet ray. After this initial treatment his pain greatly eased, less local tenderness being felt, while discharge also had increased. Another treatment was given in the afternoon of the same day when the patient felt much relieved so as to be able to sleep during the night; some pain persisted, although there was lessened discharge. The following day similar treatment was repeated and that night he found himself able to sleep well without any pain; only slight tenderness on pressure was noticed, but practically no discharge. A fourth application was given the next morning. On the following day the patient reported that all symptoms had subsided; there was no recurrence, patient being discharged as having reached maximum improvement.

Patient I. T., a case of chronic pansinusitis with severe radiating neuralgic pains in addition to acute local pain and tenderness on palpation over all sinuses and with profuse mucopurulent discharge. First treated July 2d, he obtained some relief of symptoms with the increase of discharge. Treated again on July 5th with further amelioration of symptoms, for twenty-four hours after this visit he had slight recurrence of pain. Following the next treatment, July 7th, he observed lessening discharge with lengthening periods of cessation of pain. Treatments repeated on the eleventh and fourteenth days gave final relief when the patient left on a three weeks' vacation; improvement was prompt and adequate.

P. S. had chronic bilateral ethmoiditis, with pains radiating over the orbital regions, side of head and face, that were persistent and severe. His first treatment was administered August 8th, the severe neuralgic pains being greatly relieved and the patient complaining only of a slight frontal headache which subsided the following day. He received treatment on alternate days for three weeks with marked diminution of all symptoms. The treatments were then reduced to twice a week for another two weeks, after which full relief was obtained.

T. K. complained of chronic right-sided frontal sinusitis with severe localized pain over his forehead and a profuse discharge. His first treatment, July 27th, was followed by a copious discharge of mucopurulent secretion which gave marked relief. When again treated on August 3d he remarked that his head seemed clear with marked relief of pain. Further treatments, on August 6th and 13th, brought complete subsidence of symptoms.

B. K., with a trophic rhinitis, reported for treatment February 21st, this condition having resisted all other forms of treatment. Applications made daily

for three weeks gave striking relief, the once dried-out mucosa appearing moist and soft. His visits were then reduced to alternate days for a further three weeks, after which all symptoms had been relieved. A much more normally appearing mucosa resulted, all crusty areas having cleared up.

E. R., having hypertrophic rhinitis associated with chronic antritis, left side, was admitted for treatment November 24, 1922. He was treated daily for two weeks, with relief of pain, diminished discharge and lessened congestion of the nasal mucosa. Applications were reduced to three times weekly so that after four weeks' treatment there was adequate relief.

E. B., with severe chronic post-operative sinusitis of two years' duration, reported for treatment November 24, 1922, having previously submitted to nine operations, both internal and external, these including several sinus punctures. On admission he had a profuse purulent discharge, severe headaches and neuralgia with acute tenderness on pressure over all sinuses. He received applications daily for the first two weeks, gradually showing amelioration of all symptoms; then visits were reduced to alternate days. The patient continued to make steady improvement, the discharge gradually subsiding and the pain diminishing almost entirely after four weeks' treatment. His visits were reduced to twice a week which were sufficient to hold symptoms in check and promote comfort. Treatments were continued for an additional eight weeks, being given twice a week. Patient now found himself relieved of all symptoms and also free from the troublesome acute exacerbations of symptoms and frequent colds in the head to which he had been subject since onset of the disease.

It can thus be noted that, when treatments are started during the onset of symptoms, prompt relief can be attained after a few applications; otherwise, treatments must usually include a prolonged course to reach maximum improvement.

CONCLUSIONS

Favorable results are achieved by the physiotherapy technic above described in a variety of intranasal conditions otherwise unrelieved by surgical or medical measures.

Mechanical vibration, radiant light, modified d'Arsonval and combined Oudin diathermy currents, intranasal Oudin current and intranasal ultra-violet rays are the effective modalities used.

Exact technic in application of modified diathermy and sequence in modalities employed are essential for success of the new technic.

Prompt and adequate relief of acute and chronic nasal symptoms has been obtained in otherwise seemingly incurable conditions, and this has brought much appreciation from those referring patients for such physiotherapy.

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MECHANICAL VIBRATION IN CARDIOVASCULAR CONDITIONS

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In the study of cardiovascular conditions, so replete with endogenous and exogenous phases, the indications for treatment are stimulation or inhibition. Mechanical vibration is one method by which such results may be obtained. Its mode of application is simple; the apparatus required is compact and relatively small, requiring but little space, and its care is practically nil. Its use is based on the principles of scientific medicine, the basic principles of massage, and of referred pain. It does not accomplish the impossible but is curative or palliative in action within its limitations, according to conditions presented. Removal of the cause, if possible, or its treatment is a fundamental principle.

There are many types of mechanical vibrators on the market which offer a wide selection, but the impairment of vibratory efficiency caused by interference by pressure must be recognized. When medium or heavy pressure is desired when using some of the portable vibrators, the motion is sometimes so inhibited as to render the apparatus practically worthless. If a flexible shaft vibrator is selected, see that the shaft is actually flexible, for a so-called flexible shaft that is fairly rigid is but an annoyance and eventually an expense to the operator. In the selection of vibratodes a rubber-covered ball and a rubber-covered disc are preferable to those of metal or vulcanite as the former have a greater resiliency which lessens the patient's discomfort.

The results obtained by mechanical vibration are through its application by friction or interruption applied with reference to the pathological condition presented, the selective adaptability of mechanical vibration to the condition and its known physiological actions for stimulation or inhibition.

Mechanical vibration when used therapeutically may be applied as interrupted—as an interrupted vibratory impulse communicated

to the body without pressure or with varying degrees of pressure, applicable to the treatment of cardiovascular conditions directly when applied over the heart or reflexly when applied to the spinal nerves. When applied over the heart to induce a reflex cardiac contraction, which method is preferred by some patients, the disc vibratode is used interruptedly for about one and one-half or two minutes. It may also be applied as vibratory friction in deficiency of compensatory hypertrophy of the heart associated with valvular lesions or pulmonary circulatory obstructions when used centrifugally, in which case a soft rubber disc vibratode should be employed. As interrupted or frictional vibration it is beneficial in the treatment of weak heart-muscles (1) due to poor nutrition, anæmia or increase of fat, (2) when passive congestion is due to myocardial insufficiency, (3) when valvular lesions are present, (4) as an auxiliary to regulated exercise.

In the study of blood-pressure we must not overlook the factors, normally, by which it is affected, such as the strength of the heart, peripheral resistance, vessel elasticity, and volume of blood in the body and indirectly the normality of all organs. Œdema and asphyxia are pathological factors affecting it.

Myocardial weakness may be associated with high or low blood-pressure, dependent on vasomotor tonicity, whether compensatory or deficient. As a test [1] of myocardial insufficiency, register the pulse-rate with the patient lying and sitting, and compare results. Normally it should be higher sitting, from 4 to 6 beats. If found reversed, myocardial insufficiency exists. To test [2] the vasomotor tonicity register the blood-pressure with the patient lying and sitting, which normally is six or eight millimetres higher in the sitting position. If found reversed, higher lying than sitting, vasomotor tonal deficiency is present, which as a rule is due to dilated splanchnic blood-vessels.

Loss of tonicity by the heart-muscle results in muscular relaxation accompanied by resultant murmurs noticeable during a rest period, but eliminated by exertion. These cases where exercise acts as a cardiac tonic are particularly amenable to vibratory treatment. They are often associated with a reversed systolic postural relationship as well as a higher pulse lying than sitting. A short vibratory

Fig. 1.

Fig. 2.

Correct mode of application of vibratode to right intervertebral space. Tips of index and middle fingers on spines of adjacent vertebræ so as to avoid impinging on transverse processes.

Vibratode applied to left intervertebral space. Tip of middle finger remains on same spines of vertebræ as in Fig. 1, but thumb replaces index finger, again to avoid striking transverse processes.

treatment for two minutes between the seventh cervical and first dorsal vertebræ alternately from side to side will lessen or eliminate the murmur and give the patient a sense of well being.

Apical presystolic murmurs, sometimes following rheumatic fever, are treated with a one and one-half or two-minute mechanical vibratory treatment with the ball vibratode in the intervertebral spaces alternately from side to side between the seventh cervical and first dorsal vertebræ (Figs. 1 and 2). The results are usually an improved heart form as demonstrable with a radiogram, indicating increased tonicity, the force is strengthened, and the murmur diminished.

The following is the report of a case of premature contraction (extrasystoles):

CASE I.—Joe W., aged nine years, case of premature contraction (extrasystoles) and it is diagnosed from heart-block by the rhythm of the heart. The patient complained of pain over the heart and was a picture of distress.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	100	62	38	104
Sitting	96	64	32	100

The reading showed a reversal of the normal relation of the systolic blood-pressures, lying and sitting, and a reversal of the normal relations of the pulse-rate.

The electrocardiogram [3] showed it to be a case of premature ventricular contraction. In this case, auto-intoxication was the main cause which was to be eliminated. Overexertion exaggerated the condition. Referring to the reading above, the reversed relation of the pulse-rate indicates lack of tone of the heart-muscle, and the reversed postural relation of the systolic blood-pressure shows lack of vasomotor tone, indicating dilated blood-vessels, possibly in the splanchnic area. The treatment indicated is to remove the underlying cause, regulate habits of diet and exercise, tone up the heart and contract the dilated vessels.

A subsequent record noted in this case was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	94	48	46	96
Sitting	100	44	56	96

A five-minute vibratory treatment in the intervertebral spaces from the second to the sixth dorsal vertebra especially to affect the

pulse-rate, applied with the ball vibratode, alternately from side to side from above downward, gave the following result:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	96	44	52	88
Sitting	98	50	48	92

The result was an improved diastolic scale (ascending), a lowered pulse-pressure sitting with restoration of a normal scale (descending), and a lowered pulse-rate lying and sitting in proper ratio. His following treatments consisted of two-minute vibratory applications with the ball vibratode applied interruptedly between the seventh cervical and first dorsal vertebræ alternately from side to side with moderate pressure followed by a twenty-minute application of the static wave current over the liver to enhance activity as the patient was toxic. His last electrocardiogram showed simply a slight right-sided hypertrophy. This boy was soon able to resume his attendance at school and led a normal life.

Tachycardia when associated with exophthalmic goitre or chorea is best controlled by a five-minute mechanical vibratory treatment in the intervertebral spaces from the second to the sixth dorsal vertebra alternately from side to side and from above downward. In some cases of chorea where a slight systolic murmur is present, an additional two-minute vibratory treatment between the seventh cervical and first dorsal vertebræ is beneficial and often curative.

Of cardiovascular conditions in general, hypertension and hypotension are of prime import.

Hypertension is usually of toxic origin including endocrinal imbalance with its sequelæ of disturbances. According to Sajous,[4] poisons in the blood stimulate the adrenals to destroy the poisons. " The cells of the vascular walls " are affected by the surplus of the adrenal secretion and the large vessels suffer from malnutrition, and sclerosis and calcareous degeneration follow with resulting arteriosclerosis. If nephritis follows valvular heart disease,[5] hypertension in such cases may be considered secondary and is an arterial disorder.[6] In many cases of hypertension, intestinal toxicity is present, and a careful study is necessary in considering treatment to determine its cause—valvular insufficiency, ptosis, a tight rectum, a rigid anus, an incomplete ileocæcal valve, improper diet, a sluggish liver

or one of the many causes associated with constipation. A general clearing out of the bowels is a requisite regardless of the method of treatment for the hypertension. Hypertension may be " incident [7] to a primary cardiac condition, such as aortic insufficiency."

Hypertension may be primary as of myocardial origin caused by inflammation, simple or toxic, including endocrinal instability or faulty nutrition. When secondary, it may follow high blood-pressure as is occasionally seen in the asthenic stage of goitre, or following hypertension after a series of X-ray exposures as in the treatment of malignant conditions.

An associated condition of hypertension, as well as that of hypotension, often noted is a vasomotor tonal deficiency resulting in a change from the normal of the postural relationship of systolic blood-pressure. Some have called it a blood ptosis. This is a symptom of splanchnic neurasthenia of which there are many cases to be found in general practice. It is also characterized by a nervous depression, sensitive abdomen, an engorged liver, gastroptosis, enteroptosis or both, and a feeling of fatigue without warrant. It is often associated with incipient tuberculosis and gastro-intestinal disorders. In a few cases, myocardial insufficiency may be present. In our experience, cases of splanchnic neurasthenia of long standing occasionally terminate in sudden death, ascribed to cardiac failure or acute indigestion.

When examining a patient it is important that the pressure be always taken by the same person, with the same width of cuff applied over the bared arm, and in the same position under as nearly identical conditions at the same time of day. Howell [8] states, " In determinations of blood-pressure in the brachial artery of man care must be taken to keep the arm in the same position in a series of observations in order to equalize the hydrostatic factor. The importance of this gravity is most evident in the case of the abdominal (splanchnic) circulation." The pressure should be taken as quickly as possible, as constriction over a vessel [9] for one minute may cause a raise of 5 mm. Hg. and " continued compression may cause a rise up to 20 mm." A second reading may also make a difference. Systolic, diastolic and pulse readings should always be taken lying and

sitting, and also in the standing posture if a more detailed study be desired.

In a study of the literature, postural relationship as regards pulse-pressure or blood-pressure is an ignored or mooted question. Some authors consider a higher systolic blood-pressure lying than standing as normal. Erlanger and Hooker,[10] after a most extensive study of the two subjects, state, "When the standing posture is assumed from the recumbent or the sitting posture, the blood-pressure may either rise or fall, the result probably depending largely upon attendant circumstances, such as external temperature, activity of the digestive organs, etc., but pulse-pressure is always diminished and the pulse-rate increased. When conditions are constant the velocity of blood flow is presumably the same in all postures"—velocity representing the product of pulse-pressure by the pulse-rate. Our reports of many cases in years of practice agree with the first part of the preceding statement, but those cases showing a fall of blood-pressure on a change from recumbency to the sitting posture in our belief have presented symptoms of blood ptosis or preferably of vasomotor tonal deficiency. Our cases that were seemingly in all respects normal gave higher systolic pressures in increasing ratio representing an ascending scale on the change of position from recumbency to sitting in accord with W. H. Cowing's [11] findings. "Pressure readings (systolic) are always higher when standing than when sitting, and higher sitting than reclining, the differences being from four to eight millimetres in each change of position." It might be in order here to note that Erlanger's and Hooker's subjects, on whom "Effect of Posture" tables were tabulated, showed vasomotor tonal deficiency. Subject *N,* presumably physically normal, showed a higher blood-pressure lying than standing on comparison of the first readings, respectively, in his second chart,[12] and the record [13] of subject *A,* an orthostatic albuminuric, showed when first taken lying, maximum 120 and standing, 112. Our normal diastolic readings showed an increase, or ascending, scale and normal pulse-pressure readings were represented by a descending scale, whereas the pulse-rate increased on changing from recumbency to the sitting posture. It is worthy of note that "in a series [14] of observations made upon forty-nine patients at the Vanderbilt Clinic as to the effect upon

the blood-pressure of assuming the recumbent position in a considerable majority of cases there was a definite fall of blood-pressure, in one case forty-four millimetres in ten minutes." This subject of postural relationship suggests the question as to whether a systolic descending scale relationship, regarded by some as a normal systolic scale, is not representative of a large proportion of the human race who lack vasomotor tonicity?

Howell [15] notes " that under normal conditions the peripheral resistance in this great area (splanchnic) plays a predominating part in the maintenance of normal arterial pressure, and by the same reasoning variations in tone in the arteries of this region must play a very large part in the regulation of arterial pressure." Erlanger and Hooker[16] acknowledge that " the changes of the circulatory conditions when the erect posture is assumed are induced mainly by the action of gravity and are probably elicited by ' bleeding ' into the lower extremities. The effect is compensated by peripheral constriction and by an increase in the energy of the heart."

The systolic pressure compensatory to the diastolic pressure is often considered most important, but by those who have given the subject much thought it is regarded as least dependable being subject to psychic influences. The diastolic [17] is " more reliable and stable." Sir Lauder Brunton [18] considers that by its amount and the pulse-pressure, " we obtain valuable data in regard to the strength of the heart and condition of the arterioles." Erlanger and Hooker [19] also observed a close relationship between urinary output and " the magnitude of the pulse pressure," both usually varying " in the same direction." [20]

The following case reports are illustrative of mechanical vibratory application in cases of hypertension, hypotension, and vasomotor tonal deficiency:

CASE II.—Mrs. W., case of hypertension.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	160	96	64	72
Sitting	164	112	52	76

As this was a simple case of hypertension, a five-minute vibratory treatment was given with the ball vibratode in the intervertebral spaces between the second and third, and third and fourth dorsal

vertebræ, alternately from side to side from above downward, with the following result:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	136	80	56	76
Sitting	138	88	50	76

The systolic pressures were lowered 24 mm. and 26 mm. sitting, and the diastolic pressures were lowered 16 mm. and 24 mm., respectively, and the ascending scales preserved; the pulse-pressures were diminished with a normal descending scale. Foster [21] believes if the heart beat is not markedly changed with a lowered blood-pressure, the fall of pressure must be due " to the diminution of peripheral resistance occasioned by the dilation of some arteries." He believes that possibly " those dilated are chiefly those of the abdominal viscera governed by the splanchnic nerves."

CASE III.—Dr. S., hypertension with myocarditis. These cases require not only a reduction of the blood-pressure but an increase of cardiac tone.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	172	88	84	92
Sitting	184	96	88	92

After a five-minute mechanical vibratory treatment with a hard-rubber ball vibratode, not a vulcanite ball, applied in the intervertebral spaces alternately from side to side from above downward, from the second to the sixth dorsal vertebra, because not only was the systolic pressure high but the pulse-rate as well, the result was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	164	104	60	76
Sitting	184	106	78	84

The reading showed a lowered systolic pressure lying, increased diastolic pressures, lowered pulse-pressures, and a reduction in the pulse-rates, with diminished velocity of the blood $84 \times 92 = 7728$ as compared with $60 \times 76 = 4560$, and $88 \times 92 = 8096$ as compared with $78 \times 84 = 6552$.

After a two-minute vibratory treatment with the ball vibratode applied between the seventh cervical and first dorsal vertebræ alternately from side to side, as the pulse reading at first was the same,

92 and 92, showing myocardial neutrality as to tone, the result was as follows:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	134	92	42	76
Sitting	152	94	58	84

The immediate result showed a fall in the systolic pressures of 28 mm. and 32 mm., a fall in the diastolic pressures, a fall in pulse-pressure and no change in the pulse-rate. The velocity of the blood was diminished as represented by $42 \times 76 = 3192$ as compared with $60 \times 76 = 4560$, and $58 \times 84 = 4872$ as compared with $78 \times 84 = 6552$. It is noted that the pulse-rate was not changed after the last vibratory treatment. So it is probable that the fall was due to lessened peripheral resistance by arterial dilation possibly in the splanchnic vessels. The final results show notably a fall of systolic pressures from 172 mm. to 134 mm. lying and from 184 mm. to 152 mm. sitting and a marked change in the pulse-pressures. It is also in order to note that vagal stimulation [22] gives a sudden fall in blood-pressure as noted in this case from 184 to 152 in the systolic pressure when sitting. This was the patient's first treatment, whereas the pulse-pressure is lowered it does not represent the normal scale (descending), an improvement to be looked for after further treatments.

One of the greatest falls observed in the treatment of hypertension was in the case of Mr. P. (Fig. 3).

CASE IV.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	188	56	132	70
Sitting	224	96	128	76

As this patient had previously shown a tendency to a higher pressure lying than sitting, he received a five-minute vibratory treatment with the ball vibratode in the intervertebral spaces from the second to the sixth dorsal vertebra alternately from above downward with the following result:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	134	86	48	66
Sitting	150	98	52	70

The systolic pressures were lessened by 54 mm. lying and 74 mm. sitting, the diastolics were increased both with a preservation of an

ascending scale and the pulse-pressure was markedly diminished, 84 mm. and 76 mm., respectively, though the postural relationship is not as yet normal, and the pulse-rate lowered, remained in the same scale as before.

CASE V.—Mr. E., case of hypertension; had had a stroke.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	172	100	72	82
Sitting	184	126	58	80
Standing	194	150	44	96

Whereas this patient presents systolic and diastolic ascending scales and a descending pulse-pressure scale from recumbency to standing which is a normal tendency, the systolic pressures are too high, the diastolic too high and, also, the pulse-rate which is lower sitting than lying or standing.

After a five-minute vibratory treatment from the second to the sixth dorsal vertebra, from above downward alternately from side to side in the intervertebral spaces with the ball vibratode, the result was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	134	98	36	84
Sitting	152	110	42	92
Standing	158	120	38	84

The treatment, while preserving their scales normally ascending, reduced the systolic and diastolic pressures, the systolic lying 38 mm. and standing 36 mm., besides reducing all the pulse-pressures, the one lying 36 mm., which is an improvement on the picture as presented, and the pulse-pressure scale sitting and standing is in normal ratio but not lying and sitting.   The velocity of the blood was diminished as

$$36 \times 84 < 72 \times 82$$
$$42 \times 92 < 58 \times 80$$
$$38 \times 84 < 44 \times 96$$

CASE VI.—Mr. M., case of hypertension with neutral vasomotor tonicity.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	184	98	86	84
Sitting	184	112	72	96

When the diastolic is over 95 or 100, we deem frequent examination of the urine advisable.

After a five-minute vibratory treatment in the intervertebral spaces, alternately from side to side, from above downward from the second to the sixth dorsal vertebra, as there was hypertension with neutral vasomotor tonicity, the result was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	122	84	38	84
Sitting	138	98	40	88

Systolic pressures were reduced and a normal ascending scale restored, the diastolic pressures were reduced and a normal scale preserved, the pulse-pressures were reduced but the scale is slightly ascending, and the pulse ratio was improved. The velocity of the blood flow was diminished lying from $86 \times 84 = 7224$ to 3192 and sitting from $72 \times 84 = 6048$ to 3520.

CASE VII.—Mr. W., a case of suddenly developed hypertension with associated vasomotor tonal deficiency.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	176	116	60	not recorded
Sitting	168	114	54	

After a five-minute vibratory treatment with the ball vibratode from the second to the sixth dorsal vertebra, alternately from side to side, from above downward, on account of vasomotor tonal deficiency with the high systolic pressures, the reading was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	112	84	28	80
Sitting	120	80	40	84

Whereas there was a drop of 64 mm. and 48 mm., respectively, in the systolic pressures with a correction of postural relationship, a lowering of the diastolic pressures and also of the pulse-pressures the scales of the diastolic and pulse-pressure readings are not as yet of the proper order. This reading will illustrate the fallacy of relying wholly on the reading of systolic and diastolic pressures taken in but one position or of systolic pressures.

CASE VIII.—Mr. S., case of hypotension.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	98	56	42	84
Sitting	102	70	32	92

A two-minute vibratory treatment between the seventh cervical

and first dorsal vertebræ to tone up the heart, which it will do as shown by radiograms, gave

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	106	70	36	88
Sitting	116	90	26	94

The result was a rise in the systolic and diastolic pressures with normal ascending scale, a fall in the pulse-pressures with a normal descending scale and an increased pulse-rate with normal ascending scale. The velocity of the blood was diminished as $36 \times 88 = 3168 < 42 \times 84 = 3528$ and $26 \times 94 = 2444 < 32 \times 92 = 2944$. Hurthle [23] found experimentally " that the rise in the blood-pressure that results from stimulation of the splanchnic nerve is accompanied by a diminution of pulse-pressure " and it is thought the rise " is brought about by an increase in the peripheral resistance. Increasing the peripheral resistance diminishes the velocity of the blood flow. It also diminishes the pulse-pressure." (Marey, Hofmeister, Hurthle.[24]) Was the splanchnic nerve stimulated?

CASE IX.—Miss M. A., case of hypotension with vasomotor tonal deficiency.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	102	80	22	72
Sitting	100	82	18	80

After a two-minute vibratory treatment between the seventh cervical and first dorsal vertebræ, alternately from side to side, to tone up the heart, and a two-minute vibratory treatment over the second cervical to raise the blood-pressure, the result was

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	108	78	30	78
Sitting	114	86	28	82

The systolic pressures were raised and the normal ascending scale restored. The diastolic was changed to an improved ascending scale and the pulse-pressures raised with a normal descending scale, the pulse-rate being increased, and an ascending scale being preserved. The velocity of the blood was increased. It is a question as to whether vibratory treatment of the second cervical does not increase the thyroid secretion in the blood. Rogoff [25] reports that such was produced experimentally in a dog " during massage and during stimulation of the cervical sympathetic nerve."

Fɪɢ. 3.
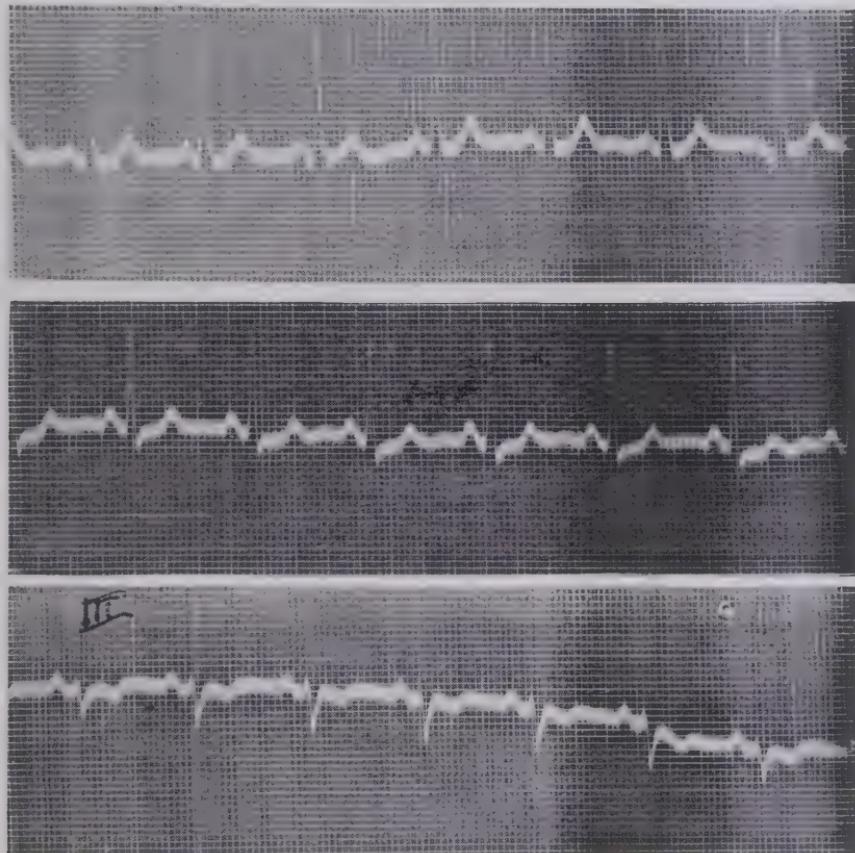
The electrocardiogram shows marked left-sided hypertrophy. On physical examination there was enlargement of the heart to the left, the beats being regular and the sounds of good quality, along with marked aortic accentuations to the second sound. (Case IV.)

Fig. 4.

Lead I

Lead II.

Lead III
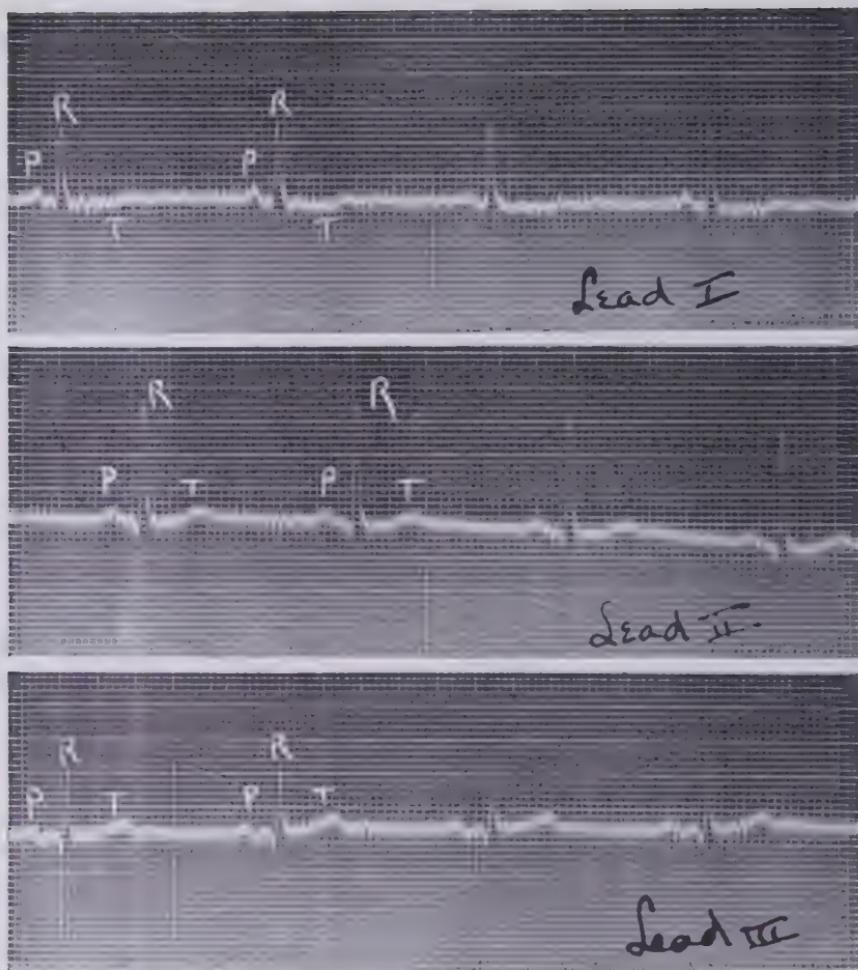
Mr. M., case of dilated aorta.

Fig. 5.

Case XI.—Mr. M.

CASE X.—Mrs. D., a case of hypotension with neutral vasomotor tonicity.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	110	72	38	92
Sitting	110	70	40	90

The systolic pressures are identical, the diastolic represents a descending instead of a normal ascending scale; the pulse-pressures show an ascending instead of a normal descending scale, and the pulse-rate shows a descending instead of a normal ascending scale.

After a two-minute vibratory treatment with the ball vibratode between the seventh cervical and first dorsal vertebræ the following resulted:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	120	70	50	84
Sitting	124	80	44	86

The normal postural relationships of the systolic and diastolic pulse-pressures and pulse-rates are respectively restored and the velocity of the blood flow is increased as $50 \times 84 > 38 \times 92$ and $44 \times 86 > 40 \times 90$. The treatment induced reflex contraction of the heart with increase of heart tone.

CASE XI.—Mr. M., a case of special interest. (Figs. 4 and 5.) Patient had been in bed for months under treatment with digitalis by his physician, and was so affected, especially with pain and dyspnœa, that he had been unable to reach the office. The electrocardiogram bore a striking similarity to that of an aortic aneurism and a radiogram confirmed the aortic enlargement.

His record follows:

	Systolic	Diastolic	Pulse-pressure
Lying	128	60	68
Sitting	136	82	54

Over popliteal artery:

	Systolic	Diastolic	Pulse-pressure
Lying	156	114	42

There was a difference in the systolic pressures lying of 28 millimetres simulating Dr. Leonard Hall's findings [26] in aortic regurgitation. In health, blood-pressure is about the same in the brachial and femoral arteries but in aortic regurgitation the readings from the femoral are much higher. " The arterial blood-pressure in most cases of aneurism of the thoracic aorta or innominate is either normal or slightly above normal. As a rule, however, it is much higher in cases of mere dilatation of the aorta." [27]

Vibratory treatment was given for two minutes between the seventh cervical and first dorsal vertebræ to induce aortic contraction reflexly with the relief of the dyspnœa. He was soon able to go on a vacation, during which time his wife reported his continued improvement.

On his return he resumed treatments and was able to go to work. About two months ago he had double pneumonia, and was sent to a hospital, but the doctors reported his heart in good condition notwithstanding the great tax put upon it.

The following records a series of observations:

CASE XII.—Dr. H., feeble and incapacitated for work, presented himself for treatment January 2, 1923. He gave a history of hypertension and myocarditis, his record being as follows:

February 2, 1923

	Systolic	Diastolic	Pulse-pressure	Pulse-rate	
Lying	192	94	98	76 ⎫	irregular
Sitting	178	106	72	88 ⎭	

As there was a reversed systolic pressure showing vasomotor tonal deficiency, a five-minute vibratory treatment was given in the intervertebral spaces from side to side from the second to the sixth dorsal vertebra from above downward.

The result was

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	146	78	68	72
Sitting	138	68	70	84

Although not representative of normal postural relationship, the systolic difference was reduced from 14 to 8 and there was a reduction of diastolic pressures, pulse-pressures, and pulse-rates.

In subsequent treatments a five-minute mechanical vibratory application was made from the second to the sixth dorsal vertebra if the systolic pressures were high and reversed; otherwise, a two-minute vibratory treatment was given between the seventh cervical and first dorsal vertebræ to increase the tone of the heart, and occasionally this was supplemented by a two-minute vibratory treatment over the second cervical vertebra to raise the pressure when very low.

His record on June 7, 1923, was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate	Observation
Lying	120	70	50	64	7 skips per minute
Sitting	112	62	50	96	

A five-minute vibratory treatment from the second to the sixth dorsal vertebra was followed by a two-minute vibratory treatment between the seventh cervical and first dorsal vertebræ, with the following result:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate	Observation
Lying	120	70	50	60	No skips
Sitting	100	64	36	80	

The systolic is still reversed, but the pulse-pressure has improved and the difference in pulse-rate has changed from 32 to 20.

His record on June 19, 1923, read:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	114	78	36	78
Sitting	110	68	32	88

A five-minute vibratory treatment from the second to the sixth dorsal vertebra, as heretofore described, gave—

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	110	66	44	68
Sitting	110	60	50	70

After a two-minute vibratory treatment, between the seventh cervical and first dorsal vertebræ, the reading was:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	110	60	50	68
Sitting	106	66	40	72

Although the systolic shows a reversal the diastolic is restored to a normal scale (ascending) and the pulse-pressure scale is normal (descending).

This patient resumed his duties and was able to enjoy a vacation. When he returned for treatment in November, 1923, his report read:

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	108	72	36	84
Sitting	104	64	40	80

His treatment was a two-minute vibratory application between the seventh cervical and first dorsal vertebræ and a two-minute vibratory treatment over the second cervical vertebra.

November 21, 1923

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	114	62	52	68
Sitting	110	66	44	72

December 3, 1923

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	110	68	42	64
Sitting	118	70	48	68

December 31, 1923

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
Lying	108	56	52	68
Sitting	112	62	50	76

The patient is attending to professional and civic duties beyond his powers of endurance.

The following is a record of a case where vibratory treatment was given from the second to the sixth dorsal vertebra:

CASE XIII.

	Systolic	Diastolic	Pulse-pressure	Pulse-rate
January 15, 1923				
Lying	270	150	120	92
Sitting	294	138	156	96
After treatment:				
Lying	240	106	134	84
Sitting	238	120	118	84
January 16, 1923				
Lying	178	94	84	no record
Sitting	204	110	94	no record
January 17, 1923				
Lying	222	136	86	80
Sitting	226	130	96	80
After treatment:				
Lying	190	124	66	76
Sitting	202	124	78	78
January 18, 1923				
Lying	204	126	78	84
Sitting	198	114	84	82
January 20, 1923				
Lying	200	118	82	84
Sitting	194	118	76	84
January 22, 1923				
Lying	180	100	80	82
Sitting	186	108	78	88

The last record shows normal postural relationship scales throughout and the systolic drop sitting is 108 mm. with a lowered pulse-pressure.

CONCLUSIONS

(1) Mechanical vibration has a selective field in cardiovascular conditions.

(2) Mechanical vibration in functional cardiac tonal deficiency, where the heart-muscle is not diseased, is capable of increasing the tone of the heart either directly or reflexly by nerve stimulation.

(3) Mechanical vibration lowers the pulse-rate when given for five minutes in the intervertebral spaces from the second to the sixth dorsal vertebra, alternately from side to side, from above downward.

(4) A careful consideration of the normal scales of blood-pressure, systolic and diastolic, and of pulse-pressure, respectively, and of the pulse will aid in prognosis and treatment.

(5) A comparative study of the results obtained by mechanical vibratory stimulation or any other mode of stimulation, in respect to blood-pressures (systolic, diastolic), pulse-pressures, and pulse-rates in relation to posture and the velocity of the blood, will assist in standardizing treatments.

(6) Hypertension, when not secondary and uncomplicated, is usually reduced by a five-minute vibratory treatment between the second and third, and third and fourth dorsal vertebræ with the ball vibratode alternately from side to side from above downward.

(7) Hypotension, when primary, is treated palliatively or curatively by inducing the cardiac reflex of contraction by toning up the heart with a two-minute vibratory treatment with the ball vibratode between the seventh cervical and first dorsal vertebræ. Bishop states: [28] " In primary low arterial tension the heart-muscle is in a position to·recover its tone if depleted by acute disease, or to develop a compensatory hypertrophy if overtaxed by defective valves. A two-minute vibratory treatment interruptedly over the second cervical vertebra will often raise the blood-pressure."

(8) Vasomotor tonal deficiency with hypertension is corrected or aided by a five-minute vibratory treatment in the intervertebral spaces from the second to the sixth dorsal vertebra, alternately from side to side, from above downward with the ball vibratode.

(9) Vasomotor tonal deficiency with hypotension, when primary, is as a rule best treated by a two-minute vibratory treatment between the seventh cervical and first dorsal vertebræ with the ball vibratode.

Exceptions are usually amenable to a vibratory treatment from the second to the sixth dorsal vertebra.

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THE INFLUENCE OF X-RAYS AND ALLIED SUBSTANCES ON LIVING TISSUES

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In November, 1895, Prof. Wilhelm Konrad Röntgen, of the University of Würzburg, announced to the world his astounding and epoch-making discovery of the peculiar properties of a group of cathode rays of light, which, because of their remarkable penetrating power, render it possible to photograph substances through certain other substances that are opaque to ordinary light. With becoming modesty the German scientist termed these rays the " unknown " or " X-rays," by which name, as well as by that of their distinguished discoverer, they are now generally known the world over. Shortly after this great discovery, in 1898, Madame Curie gave to the world radium with its curious property of radio-activity.

The applicability of the X-rays and radium to medical science was quickly appreciated by the profession. Especially was their usefulness recognized at first in the practice of surgery in its different aspects. Their employment in embryology and obstetrics, as well as in internal medicine, were later developments.

No great gift of nature comes unalloyed with evil. No one dreamed of the deadly possibilities lurking in these unseen but powerful light rays. Their fascinating properties lured the unsuspecting delvers into the mysteries of science—who, at first, regarded the rays as amusing and wonderful toys—to further and deeper dabblings with the mysterious force. Then, slowly but surely, the eyes of the world were opened to the serious and even fatal results that might, and all too soon did, follow the indiscriminate and careless use of the rays. Serious and chronically persistent cutaneous burns developed in those who were long exposed to their action. A temporary inhibition of the generative function of the radiographers then was noticed; and, finally, one by one, the pioneers of the X-ray laboratories developed a progressive cancerous involvement of the

fingers and hands which ultimately swept them away, true martyrs to scientific progress.

These startling and unexpected developments following the indiscriminate use of the rays led to various lines of investigation into their limitations and their proper application to medical science. The rays had begun to be extensively used in the treatment of various cutaneous and gynæcological conditions, and the logical inquiry followed: If this agent has proved itself destructive, or, at least, inhibitory to the masculine generative function is it not rational to suppose that a similar deleterious effect may be noted upon ovarian tissue? Might not the action of the cathode rays so alter the ovarian generative cells as to temporarily abolish or even totally destroy their procreative power; or, if not this, might it not render the cells so morbid in function as to give origin to defective or deformed offspring? Furthermore, even if apparently healthy offspring resulted, what action might these rays have upon the various embryonic tissues insofar as the rapidity and degree of their development was concerned?

Obviously, here were thoughts well worth careful investigation. Naturally and logically, the first efforts toward the solution of these problems were directed toward the findings of the biological experimental laboratories; later came the practical results as noted by the clinicians, those in active medical and surgical practice.

THE BIOLOGICAL EFFECTS OF X-RAYS

Very shortly after the discovery of the X-rays and radium it became generally known that animal and plant life can be profoundly influenced by radio-activity. A large amount of experimentation has been done in this line, and the results obtained prove the powerful action of these agents upon living matter. In reviewing these biological effects we cannot do better at the start than quote the remarkable generalization of the subject as given by Prof. W. M. Baldwin, of Union University Medical College, of Albany, New York (1920):

" The biological effects of X-rays have been studied by a number of investigators whose work has been frequently referred to in the general field of experimentation. * * * The character of the changes brought and the nature and specificity of the cytologic varia-

tions and also the gross structural reactions to this form of energy have been considered by Mueller, Petry, Ghilarducci, Milani, Halberstaedter, Unzeitig, Guilleminot, Szilard, Degrais, Krönig, Walther, Cardinale, Eckstein, Eden, Murphy, Richardson, Bordier, Lopriori, Galimard and Gaskell, among others.   The observations of these men go a great way toward associating the specificity of tissue reaction to the selective absorption of X-ray energy.   The demonstration of a stimulating effect upon growth and upon differentiation of tissues both in plants and in animals has been given by Schwarz, Lengfellner, Cohn, Foersterling, Krukenberg, Hastings, Runner, Gilman and Baetjer, and Haecker and Lebedinsky.   One of the most recent and most thorough studies on the question of the stimulating dosage necessary for the prolongation of life among invertebrates is that of Davey upon *Trifolium confusum.*   Pfeiffer with Schwimmermacher, and Maldiney with Thouvenin succeeded in increasing the germinability of seeds; while Menetrier and Mallet, Rountree, Benjamin, Reuss, Slenka and Schwartz, Promsy and Drevon, Gilman and Baetjer, Haecker and Lebedinsky, Aubertin and Beaujard, and Murphy and Norton succeeded in accelerating growth. The condition of sterility in the silkworm, in rats, in guinea-pigs, in cats, and in dogs, brought about through the influence of X-rays, has been studied by Regaud and Nogier, Trillwich, Barratt and Arnold, Hastings, Beckton and Wedd, Seldin, Bergonié and Tribondeau, Fraenkel, and Regaud and Dubreuil.   Bardeen, moreover, observed that the phenomenon of regeneration of lost parts in lower animals is lost after exposure to X-rays.   The results of Lecercle's experiments, where, upon raying the hindquarters of rabbits, there is a lowering of the rectal temperature for one and one-half hours afterwards, are difficult of interpretation.

   " It has been recognized, moreover, that X-ray energy will produce definite changes in certain chemical substances.   *   *   * Studies of the action of ultra-violet light rays have produced proof that proteins, carbohydrates, and lipins may be chemically altered by means of this form of energy.   To review the experimental results briefly: Massol and Kluyver have ascertained that starches may be altered, and Stoklasa, Zdobnicky, Chauchard and Mazoné, and Pougnet that they may be ultimately broken up.   Diastase may be

liberated in plants (Maquenne and Demoussy). Bierry, Henri and Ranc have inverted cane-sugar. Agulhon, Maurain and Warcollier, and Raybaud presented evidence that the action of enzymes in the presence of oxygen was weakened and destroyed by ultra-violet light. Furthermore, albumin may be coagulated (Bovie) and the iodine content of fats may be lowered (Droste, Roemer and Sames), * * * while a precipitation of the same element from chloroform solution has been observed by Bordier and Galimard. Starch has been transformed to dextrin (Colwell and Russ). Certain dehydrating effects upon chemical compounds have been observed by Bordier and Galimard. Werner studied the reaction of these rays with cholin. Solutions have been altered in chemical constitution (Schwartz), while the effects of radiation on fermentation and on enzymes have been studied in connection with substances such as must, wine, vinegar, alcohol, butter, milk, eggs, and other agricultural products (Bruttini and Richards).

"As related to cellular activity and the phenomena of mitosis, the work of Lepine and Boulud commands attention. These investigators determined that X-rays increased the glycolytic power of the cells. The mitotic activity of the cells was observed to be reduced by Gaskell; in *Ascaris*, Perthes noted it to be delayed, while the activity of protoplasmic movement was found by Seckt and Lopriori to be increased, but, on the other hand, restrained through an increase in the dosage (Lopriori). A number of other investigators have recorded pathological cellular conditions, the major interest being centred in observations upon the various phenomena of chromatin alterations (Cluzet, Scholz and others).

"Summarizing the facts having a biological significance, but at the same time allowing that those results are not all dependent directly upon X-ray energy for their cause, we find, first, that the mitotic process may be either accelerated, retarded or made abnormal; secondly, evidence has been adduced which points to a susceptibility to the rays not only of chromatin, but of cytoplasm as well; thirdly, the phenomena of differentiation and of growth may be accelerated, retarded, or rendered abnormal; fourthly, a decidedly selective action of the rays has been demonstrated by studies on adult types of tissues; and, lastly, definite changes of a chemical nature both in the proto-

plasmic content of cell-bodies and, more specifically, in enzymes may be produced by X-ray energy.

" Positive experimental evidence at present points to a definite chemical reaction which, it is not difficult to prove in the two- and four-celled ova, must be of intracellular character. This is contrary to the biological hypothesis of Hertwig.   *   *   *   We have not as yet identified the character of the chemical change affected and much less the kind of substance influenced, whether protein, lipin, or carbohydrate, but, inasmuch as the developmental end-result, both gross and microscopic, is identical in every instance, we may reasonably assume that the chemical change brought about by the X-ray energy is definite and the same in the numerous specimens. Furthermore, it is more in conformity with modern chemical ontogenetic views to assume that the pathological cytologic features characteristic of all the tissues are directly referable to the distribution to these cells of the abnormal chemical constituents. Experiments of this nature in which the defect is uniform mark, therefore, a preliminary but essential step in the chemical identification of the change experimentally induced."

FINDINGS OF THE EXPERIMENTAL BIOLOGICAL LABORATORIES

Since the investigations of Bohn (1903), twenty-one years ago, numerous inquiries have been made as to the biologic effect of the X-rays and all allied substances (radium rays and emanations, thorium, mesothorium, light rays from lamps, and the actinic rays from the sun—Finsen and Becquerel rays) upon living ova of many of the lower animals and plants. These studies have had special reference to the possibility of retardation or alteration of embryonic growth and the ultimate development of various forms of monstrosities. A brief résumé of this interesting work will be instructive:

Bacteria.—In 1896, Park, Minck, Lyon, Delepine and others found that the rays had no inhibitory or bactericidal action. Rieder (1902), however, claimed an inhibition of growth of bacteria when exposed to an intense action of the rays. Koernicke (1904–05) has described similar effects following exposure to radium, the bacteria, however, growing again when transferred to fresh unexposed gelatin. According to Chambers and Russ (1912), the α- and β-rays from comparatively small quantities of radium (a few milligrams) have

a direct bactericidal action upon the commoner pathogenic bacteria (*Staphylococcus pyogenes aureus, Bacillus coli communis, B. pyocyaneus, B. anthracis, B. tuberculosis*). Radium emanation in concentrations of less than a millicurie per c.c. has a marked bactericidal action. Agglutination of bacteria in distilled water is an early sequel to their irradiation. Bacteria are more quickly destroyed by the emanation than are opsonin and leucocytes.

Organic Substances.—Schwarz (1903) and Schaper (1904) have shown that when an egg, rich in yolk, is intensely radiated, the lecithin is decomposed into cholin which acts as a poison, while the chromatin is affected only indirectly; and Werner (1904) obtained evidence that the products of the decomposition of lecithin under the influence of radium could produce effects upon normal tissues similar to those produced by radium itself. Colwell and Russ (1912) noted the effect of X-rays upon certain proteins (blood-serum, serum-albumin, serum-globulin, Witte peptone, alanin, nucleo-albumin) and carbohydrates (starch, glycogen, cane-sugar). In only two of these substances, namely, nucleo-albumin and starch, were any changes detected. The change produced in nucleo-albumin was a physical one, while starch showed chemical changes in addition.

Plants.—Lopriori (1897, 1899) found that pollen germination was inhibited by exposure to X-rays. During the exposure the pollen-granules absorbed large amounts of water, but after the exposure the germination began again. He found a destructive action on tape-grass or eel-grass (*Vallisneria spiralis*), the pitcher-plant (*Darlingtonia*) and certain shrubs (*Genista*). Maldiney and Thouvenin (1898) reported that the germination of seeds was hastened by exposure to the rays; while Becquerel (1901) found that weak or short stimuli had small effect while longer stimuli retarded growth. Koernicke (1904, 1905) exposed the roots of the field bean (*Vicia faba*) and garden pea (*Pisum sativum*) for two days to radium, and noted that the growth of the seeds was checked although the resting nuclei appeared unaffected. Guilleminot (1907, 1909) compared the action of X-rays and that of the β-rays of radium upon plant-cells. He found that the fluorescent effect of the two being equal, the β-rays were more intense. A retardation of growth was noted when the rays were fairly strong, or abnormality or even inhibition

of development followed. Gager (1908) found budding in yeasts to be increased by exposure to radium rays. Retardation of growth followed exposure of seeds under various conditions. The changes produced were cessation of cell-division, acceleration of differentiation, a decrease in the size of the cell, and a lack of coördination in histogenesis. He proved that those processes which go to produce senescence are accelerated. Casemir (1910) described a cessation of nuclear and cell-division in germinating field beans after two and one-half hours' exposure to the röntgen-rays.

Protozoa.—Protozoa present some variations in their reaction to X-rays. Some are killed, but others are very resistant and appear little disturbed. In some cases cytoplasmic and nuclear activities are affected, while in other cases such a process as conjugation goes on apparently unaffected. There is no positive evidence of tropic responses to radiations. Schaudinn (1899) showed that some species of *Paramœcia* are decidedly susceptible to the action of X-rays. Joseph and Prowazek (1902) found that certain organisms (*Paramœcium, Daphnia*) show a negative tropism toward the X-rays. They observed certain changes in the plasma of *Paramœcia* which could be interpreted only as of the nature of an injury or exhaustion. Veneziani (1905) found that the infusorian *Opalina ranarum* retained its vitality outside the body longer when exposed to radium than when not so exposed. Zuelzer (1905) studied the action of radium on a number of protozoa and found some much more resistant than others. She stated that multiplication of *Paramœcium ambiguum* was stopped by twenty-four hours' exposure to the rays, but that *P. bursaria* was much more resistant. In those protozoa showing direct injury the nucleus appeared affected before the cytoplasm. Bardeen (1906) examined unicellular organisms (*Paramœcia*) with both macro- and micronuclei and other infusoria (*Urostyla, Oxytricha, Halteria*) and found them to be very resistant to the X-rays. They were not affected after twelve hours' exposure, no effect being observed in their morphology or on the rate of division in cultures maintained for several weeks. Bovie (1918) has shown that various protozoans are very readily cytolized by ultra-violet radiations from the Schumann region.

Silkworm.—Bordier (1905) X-rayed silkworms (*Bombyx mori*)

and found an increased restlessness and a smaller size of the worms. The cocoons were only half-size and the moths did not emerge. Hastings (1910) found that mature silkworm caterpillars could stand a relatively large dosage of the rays. On raying the larvæ he found a definite stimulating effect on the growth of the caterpillars, some of which attained unusual size. There was also an acceleration of the hatching of the eggs resulting from them. He believed, however, that the rays exert a dual influence, since evidences of a retarding influence were not wanting. Later, with Beckton and Wedd (1912), he found that not only was the hatching of the eggs accelerated, but that the second generation was less fertile. This loss of fertility gradually died out in succeeding generations.

Butterflies, Beetles, Snails, and Other Insects.—Bardeen and Baetjer (1904) noted that exposure to the X-rays inhibits the power of regeneration in fresh-water planarians. Schaper (1904) found that exposure to radium inhibits the power of regeneration in the larvæ of certain gastropods (*Triton* and *Rana fusca*). Hasebroek (1907) was able to kill the caterpillars of certain butterflies (*Charaxes*), but those of the angel-wing butterfly (*Vanessa urticæ*) after being rayed an unknown amount developed into butterflies that were unable to fly. Tur (1909) found that exposure of the eggs of the snail (*Philine operta*) to radium before the first division had no effect; exposure later than this gave rise to very abnormal larvæ. Bardeen (1911) observed that muscular and ciliary activity in planarians exposed to X-rays for considerable periods were apparently not directly affected by the exposure. Richards (1914) studied the effect of X-rays and the γ-rays of radium on the rate of cell-division in the early cleavage in eggs of the fresh-water snail (*Planorbis lentus*). He found that brief exposure produced an acceleration in the rate of cleavage; but this effect was temporary only, since after the first cleavage the treated eggs were retarded in growth. The greatest effect was produced when exposures were made during the metaphase; during the resting stage there was very little response one way or the other. Runner (1916) X-rayed the eggs of the cigarette beetle (*Lasiodermia serricorne*) and found that eggs less than three days old failed to hatch and became shrunken in about ten days. Eggs over three days old hatched, but the larvæ never

reached the pupa stage. Larvæ similarly rayed refused to eat, and although they lived a long time after raying they never reached the pupa stage. Davey (1917) noted the effect of X-rays on the length of life of flour-weevils (*Trifolium confusum*). It was found possible to destroy the eggs of these beetles with X-rays, and the beetles themselves could be killed if a sufficiently large dose were given, although they lived for several days after the exposure. Congdon (1912) and Mavor (1922–23) tried the effect of the rays on the fruit-fly (*Drosophila*). Congdon noted retardation in development in proportion to the degree of radiation both in *Drosophila* and hydranths (*Tubularia*). In the latter he found that seeds were more sensitive to radiation when the embryos were turned toward the radium. Mavor found that there was produced a specific modification of the hereditary mechanism which is inherited as such. A considerable number of exceptional daughters were obtained by submitting the mothers to X-rays before mating. A large proportion of these exceptional daughters were found to be fertile, and these bred further exceptions without having been submitted to the rays.

Intestinal Worms.—Perthes (1904), Lazarus-Barlow and Bonney (1909, 1913), Hastings (1912), P. Hertwig (1912), and Mottram (1913) have investigated the action of the X-rays on the ova of *Ascaris megalocephala* of the horse. Perthes found that the embryos were greatly retarded in growth and monstrosities occurred after the raying. These misshapen little worms were especially abnormal at the posterior end. The eggs in the resting and dividing conditions were equally affected, and the degree of exposure was the factor upon which the result depended. The nuclei and, in particular, the chromatic structures were most injured, while the spindles and centrosomes appeared quite normal. According to Lazarus-Barlow and Bonney, in small doses continued for a short time, cell-division proceeded at a faster rate than normal. In larger doses evidence of an inhibitory action was noted, even going on to total arrest of development. The formation of monstrosities and of irregular divisions indicates that cells exposed to the action of a radio-active substance enter on a disorderly cycle of changes. Hastings also found a retardation of growth after raying; while Mottram noted that dividing ova are at least eight times as vulnerable as resting ova.

The most vulnerable stage in division is the metaphase. P. Hertwig concluded that the chromatin and other nuclear structures are directly affected by radiation, as claimed by O. and G. Hertwig. She agreed with Lazarus-Barlow and Bonney that exposure causes a retardation of growth depending on the length of radiation.

Sea-urchins and Marine Worms.—Schwarz (1903) experimented with the eggs of the sea-urchin and found no evidence of inhibition of growth as the result of irradiation. Bohn, however, the same year reported malformations following irradiation of the ova of the New England sea-urchin (*Strongylocentrotus*). He believed this effect was due to the action of the β- or γ-rays. He also noted that *in vitro* radium rapidly causes cessation of motion in the spermatozoa of the sea-urchin. In commenting upon Bohn's findings, Redfield and Bright (1922) say: " In view of the small number of eggs which developed in these experiments, the possibility of contamination by sperm, the absence of information concerning the control experiments, the fact that a small percentage of certain species of echinoderm eggs tend to develop without fertilization, and the failure of Packard and ourselves to confirm the observation, great weight cannot be put in this result." Bardeen (1909) had negative results similar to those of Schwarz; while G. Hertwig (1911–12) found that the progress of division in sea-urchin eggs which had been fertilized with sperm exposed to radium bromide rays was very greatly retarded even from the first cleavage. At the end of the second day most of these eggs had died, after a decidedly irregular course of development. J. Loeb (1914) showed that ultra-violet light of short wavelength will cause the initiation of development in unfertile eggs of sea-urchins (*Arbacia*) and certain worms (*Chætopterus*); while Richards (1915) failed in an attempt to activate the eggs of *Arbacia,* the marine worm (*Nereis limbata*), and starfish (*Asterias*) by the use of X-rays. Packard (1915–16) reported that when unfertilized eggs of the marine worm and of the sea-urchin are exposed to radiations from radium and then fertilized, the fertilization-membrane which results is of unusual thickness. He concluded, however, that there is no evidence of parthenogenetic development being produced by these rays. Fertilized eggs exposed to a brief but intense radiation during the period when the germ-nuclei are approaching each other

are accelerated in their rate of cell-division.   Less intense radiation
produces less acceleration.   Exposures made during the prophase
result in an acceleration unless they are prolonged, when a retarda-
tion ensues.   During the telophase the effects are much the same
as in the prophase.   Eggs exposed during the resting stage are not
easily affected.   The power of the protoplasm and chromatin to
absorb the radiations does not change during these periods.   The
differences in the density of the chromatin during the different
phases of mitosis do not affect its absorptive power.   The changes
in the rate of cell-division following radiation are due to the direct
action of the radiations on the endo-enzymes.   Redfield and Bright
(1920) exposed the eggs of the marine worm for uniform periods
of time to radiations passing through various thicknesses of alumi-
num, and found that the β-rays of low velocity produce a greater
amount of physiological change than the same number of rays of high
velocity.   These conclusions are consistent with the view that the
physiological effects of radiations from radium and X-rays are due
to the production by them of an ionization of some substance in
the eggs.

   Amphibians.—Gilman and Baetjer (1904) observed that when
the ova of *Amblystoma* were exposed to X-rays there occurred an
apparent acceleration in development for a short time, but that the
resulting offspring were monstrous in formation, showing no external
gills, poorly developed tails, imperfect eyes, and distorted mouths.
Schaper (1904) found that similar changes occurred in other
amphibians treated with radium rays; and Wintrebert (1906) stated
that radium emanations stimulate the development of amphibian eggs
and larvæ.   Eggs, however, require weaker solutions than larvæ, and
will die in solutions favorable to the latter.   O. Hertwig (1909)
found that if the unfertilized frog's egg is radiated up to a certain
point the resulting embryo after insemination with normal sperm is
abnormal; but if the radiation is very intense the development is
haploid, the egg-nucleus having been rendered incapable of playing
its usual part in fertilization.   Bardeen (1909, 1911) from extensive
experimentations upon toads and frogs, found that spermatozoa, ripe
ova and newly fertilized ova are very susceptible to X-rays.   Both
male and female sex-cells may be so altered by the rays as to give rise

to the formation of monstrous forms, especially of the spina bifida type. The susceptibility of the male and female sex-cells is approximately equal, although the abnormalities are greater and appear earlier in development when the ova are exposed. After fertilization until cleavage begins the ova at first appear to be no more susceptible than the sex-cells before fertilization. During the earlier stages of cleavage the susceptibility of the eggs to the rays is markedly increased, but during the later stages of cleavage before closure of the blastopore the susceptibility becomes much less, and after the blastopore is closed the power of the X-rays to influence development becomes strikingly reduced. The period of greatest susceptibility is the period during which there is most rapid production of nuclear material. Exposure of females in which the eggs are still ovarian will prevent the ripening of the eggs, which remain indefinitely in the ovaries but are incapable of artificial fertilization. Exposure of the sperm or of ripe ova to intense X-rays for a considerable time seems not markedly to affect the power of fertilization. Tadpoles repeatedly exposed show no direct impairment of movement.

London (1911) killed frogs in thirteen to sixteen days after exposure to radium emanations. Their blood was of a dark color and the skin was atrophic. The classical work of the Hertwigs (1911) on the action of radiations on the eggs of amphibians and sea-urchins proves conclusively that retardation of embryonic development is a sequel to irradiation. "Normal fertilized ova when irradiated produced deformed larvæ, and the degree of destructive change varied with the amount of radium used and the duration of the exposure. Interesting results were noted when normal eggs were fertilized by irradiated spermatozoa. Heavily irradiated spermatozoa produced apparently normal young, for in this case the paternal elements merely initiated what might be called a parthenogenetic development, and were too extremely injured to combine their chromatic material with that of the maternal nucleus, while slightly irradiated spermatozoa produced variously deformed young." The embryos were smaller in size, of monstrous form (dropsical abdomen and atrophied tail) and bloodless in appearance. The disturbance produced by spermatozoa exposed to rays was much less than that which resulted from an equally long exposure of the fertilized eggs

to radium rays of the same intensity. "This result is in perfect harmony with the conception of the nature of fertilization which is suggested by microscopic research, namely, that the fertilized egg is a dual organism resulting from the coalescence of two cells, one of which is furnished by each parent. The radium rays act principally on the nucleus—a strong argument in favor of the theory that the nuclei of the sperm-cell and the ovum-cell are the vehicles by which hereditary characters are transmitted from parents to offspring."

Baldwin (1915, 1919–20) has found that a condition of spina bifida in tadpoles may be produced at will and the level of the bifurcation of the neural tube be predetermined by illuminating small surface areas of the fertilized ovum of the frog by means of ultra-violet light of intensity sufficient to kill the area exposed in from ten to thirty seconds. The deformity, he believed, was probably the result of certain chemical changes in the egg. He remarks: "The various chemicals, such as salts of sodium and lithium, which have been used by Morgan, Hertwig, Herbst, Jenkinson and others in the production of spina bifida, have produced their effect by acting upon portions of the yolk hemisphere and not necessarily upon the proanlagen (chemical organ-building substances or ferments) restricted to the pigmented hemispheres." Baldwin describes the deformed embryos as "folded or U-shaped"; the viscera of these embryos developed normally in shape and size, and no defects could be recognized in the muscle-segments.

Birds and Reptiles.—Perthes (1903) found that irradiation of one wing of a young chick caused a marked inhibition of growth, the irradiated wing remaining far behind the other in its development, both bones and feathers being affected. Gilman and Baetjer (1904) found that chicks developed in eggs exposed to the rays showed malformations of the occipital region and extremities, the feathers being abnormally distributed in patches over the body. Schaper (1904) and Bohn (1904) obtained similar results with reptilian eggs. Bordier and Galimard (1905) gave incubating hens' eggs daily doses of X-rays for twenty days; the eggs contained no embryos. In specimens which had been allowed to develop somewhat before raying growth was arrested at the first dose. Gaskell (1911) X-rayed incubating hens' eggs daily and got the same results; while

Tur (1911) reported the presence of deformities in the embryos of birds irradiated through the shell of the eggs.

Mammals.—Rodet and Bertin (1898) observed the effect of X-ray irradiation on various animals. They found in those exposed a condition of paralysis with convulsions ending fatally. Autopsy showed a meningomyelitis to which they attributed the symptoms. Bergonié and Tribondeau (1904) showed that mammalian eggs are susceptible to the X-rays, and that especially the primordial follicles of the ovary were acted upon more easily than the older follicles. The same year Scholz, Seldin, and Philipp confirmed the production of azoöspermia in animals and in man by X-ray irradiation. Lepine and Boulud (1903–04) described in mammals an increased amylasis after exposure of the pancreas to the X-rays, and, in the liver and blood after moderate exposure, an increased glycogenesis and glyco-lysis; after prolonged exposure both were diminished. Warthin (1905) noted that several of the lower animals were killed by exposure to the rays. Regaud and Dubreuil (1908) believed that irradiated mammalian spermatozoa may give rise to monstrosities, just as Bardeen had shown that rayed amphibian spermatozoa may do.

Guinea-pigs.—Dominici and Barcat studied the skin of a guinea-pig which had been subjected to a therapeutic series of radium applications. The conjunctive tissue and elastic fibres were almost entirely destroyed and replaced by connective-tissue cells surrounded by dilated blood-vessels which were transformed into embryonic capillaries. This, they concluded, was a true neoplasm, because it was wanting in all phlegmasic characteristics. Oudin, Barthélemy and Darier studied X-ray alopecia in guinea-pigs. They found great thickening of all the layers of the epidermis, especially the horny layer, the individual cells, however, appearing little altered. The hair-follicles and glands showed nearly complete atrophy, traces only being found. No changes were observed in either the large or small blood-vessels or in the nerves of the cutis or subcutis.

Rollins (1901) found that two hours' daily exposure for eleven days killed the guinea-pigs. Rudis-Jicinsky (1902) examined X-ray burns in guinea-pigs and rabbits, and found evidences of a special inflammatory reaction with the development of fibrous tissue and thickening of the vessel-walls with contraction of their lumina.

Degenerative changes followed the impaired blood-supply. Albers-Schönberg (1903) found that after several hours' irradiation the animals showed necrospermia and azoöspermia, these conditions persisting for a long while and perhaps permanently. The same year Frieben found in irradiated guinea-pigs and rabbits the spleen normal, the testicles atrophic, and the epithelium of the tubules lost, without evidences of inflammatory processes. Lengfellner (1906) X-rayed three pregnant guinea-pigs three days before term. Two of the mothers were at once killed; their young died in ten minutes. The third mother had a miscarriage in five hours; the young were all dead. Regaud (1908) has been able to produce extensive alterations in the seminal epithelium of the guinea-pig, rat and rabbit without visible alterations in the blood-vessels of the testicles. Proescher (1913), with radium emanation, killed guinea-pigs in two to six hours, death resulting from respiratory paralysis, probably of central origin. The blood showed no pronounced changes save a granular disintegration of the lymphocytes. There was a hyperæmia of all the organs. Extremely high concentration of the emanations had very little effect on the erythrocytes and hematogen lymphocytes.

Rats and Mice.—Tarkhanoff (1897) experimented with mice, guinea-pigs, rabbits, birds, and frogs. After prolonged irradiation the animals died with paralytic symptoms. The reflexes were inhibited. There was an increased pigmentation of the skin in the frogs. Kienbock (1901) noted marked nervous symptoms in exposed mice, which he attributed to an inflammation of the central nervous system. Heineke (1904) experimented upon mice, rabbits, small guinea-pigs and dogs. The smaller animals died in from seven to eleven days after irradiation for several hours. The histologic changes consisted chiefly of excessive pigmentation of the spleen, disappearance of the splenic follicles, and a widespread rarefaction of the cellular elements of the splenic pulp. In the bone-marrow there was a rarefaction of the specific cells. The changes were transitory in the animals which survived, regeneration quickly taking place. Seldin (1904) found in exposed white mice, dying with paresis of the posterior extremities, an intense injection of the meninges. This was not present in larger animals. The liver-tissue in all cases was normal.

Warthin (1906) experimented on white mice, producing death in two to five days after an exposure of five hours. There was destruction of the lymphoid tissue of the spleen, the toxic symptoms increasing proportionately with the tissue loss. White rats are more sensitive than white mice, male rats apparently more so than females, young ones more so than old ones. Individual resistance, also, varies. The destruction of lymphoid tissue is more marked in the spleen than in the lymph-glands or bone-marrow. The cells chiefly affected by the rays are the young forms, the small and large lymphocytes and the myelocytes. Regeneration of lymphoid tissue is slow after prolonged or repeated exposure. Menetrier and Mallet (1907) and Rountree (1908–09) have shown by raying the ears and tails of rats that there results after moderate doses a stimulation of the growth of epithelial tissue. Guyot (1909) noticed in the skin of mice exposed to radium an increased activity in the multiplication of the cells of the malpighian layer. This used up the reserve supply of genetic cells, and ultimately the skin became denuded of epithelium. London (1911) found that young mice kept in radium emanation died on the third day with symptoms of asphyxia. Similar results were obtained by Bouchard, Curie and Bathagard in mice and guinea-pigs.

Beckton (1914–15) investigated the action of the β- and γ-rays from radium bromide, in doses of 25 to 100 milligrams, upon the excised spleen, liver and kidneys of the rat, and found that the irradiated cells, although showing no recognizable changes, are altered in such a way that they act as irritant foreign bodies and tend to malignant changes in the tissues. The autolytic ferments in the various tissues investigated were unaltered by the direct action of radium. The rays, acting upon the whole organism, can produce changes resulting in death without affecting the Altmann granules of the cells. Lazarus-Barlow (1914) studied the changes in columnar and in squamous epithelium and in the sub-epithelial tissue induced by the γ-rays of radium applied to the lower end of the rectum of the rat and the adjoining portion of the under surface of the tail. He found that the cytoplasm of the columnar cells rapidly become granular and the edges of the cells indistinct, while the nuclei swell up and become clear and pale. Some desquamation took place, and the secretion of mucus at first diminished and then became excessive.

Squamous epithelium showed alternation of the nuclei, which became swollen and clear and stained poorly. There was, also, a modification of the cytoplasm whereby its connection with neighboring cells was loosened, and desquamation of tracts of keratinized cells occurred. The moist variety was less altered from the normal than was the dry. In the muscular tissue the chief changes were noted in the circular coat near the anus and in the sphincter ani itself. These muscles became granular and œdematous and the muscle-nuclei swollen and clear. Unstriated muscle is more affected than striated. The circular coat in immediate association with the radium tube showed the greatest variation from the normal, the changes consisting in œdema and granular degeneration, the nuclei becoming swollen and clear.

Gudernatsch and Bagg (1920) injected radium emanation in a very small amount of saline solution in doses of five millicuries into pregnant rats and noticed a definite influence on the fetal and placental tissues. Some of the embryos were killed *in utero* and were gradually absorbed, thus proving that the toxic agent passes the placenta and affects the embryo directly. Other embryos not killed showed peculiar macroscopic lesions in the skin vessels. There were hemorrhagic areas along the dorsal midline or spreading over the entire body, save ventrally. These areas also appeared in the uterus and ovaries. The uterine vessels were intensely congested. The embryonic differentiating tissues were readily affected. Bagg (1922), using radium emanation of the ray type in doses equivalent to one and one-half grains of the metal radium, experimented upon the pregnant rats toward the close of gestation. The resulting offspring generally died within ten days of the irradiation, or, if living, presented cerebral defects, notably an absence of cortex together with blindness from defect of the optic tracts. The young of both sexes were also sterile. " Solutions of the active deposit of radium emanation were also used intravenously or subcutaneously in pregnant animals (the usual dose was five millicuries) and either produced death and absorption, or abortion of the young, or characteristic subcutaneous areas of extravasation in the developing embryo."

Rabbit.—Jutassy (1899) found in an irradiated rabbit exactly the same changes as those observed in the guinea-pig by Oudin, Barthélemy and Darier. Cohn rayed the heads of pregnant rabbits;

pregnancy continued to full term, and for fourteen days after birth the young seemed normal. Then they became stunted in growth, and after seven weeks were only one-third the normal size. Foersterling found that if he rayed the heads of forty-hour-old rabbits the whole animal was stunted, but if any other part of the animal was rayed only that part was stunted. Birch-Hirschfeld (1904) found in irradiated rabbits a necrosis of the ganglion-cells of the retina and a secondary atrophy of the optic nerve. Gassmann (1904) studied the histology of an X-ray ulcer in the rabbit and found a formation of clefts between the muscle-cells of the vessel-walls, a thickening of the intima and a contraction of the lumina. A cellular infiltration was present about the perineurium of the nerve-trunks. The fibrous connective-tissue bundles were broken up and surrounded by a cellular infiltration made up of plasma-cells and leucocytes. Milchner and Mosse (1904), in irradiated rabbits, confirmed the resistance of red blood-corpuscles to the action of X-rays. They found after three to four hours' exposure intense changes in the bone-marrow as shown by signs of degeneration in the white cells both of the lymphoid and myeloid series, while red cells were preserved. Barratt (1910) found that under a disc of radium bromide the skin of a rabbit, after two and one-half hours' exposure, became pale, while about the margin of the disc a circle of pigment formed. This probably indicates that pigment-carrying cells are stimulated to movement by irradiation.

Pig.—Scholz (1902) noted the effect of X-rays on the skin of young swine. He concluded that the rays affect chiefly, or exclusively, the cellular elements, causing a slow degeneration, while the connective-tissue elements are only secondarily involved in the inflammatory reaction.

Dog.—Lengfellner (1906) rayed one hind-leg of an eight-day-old puppy; seven and one-half months later this leg was 8 cm. shorter than the other. Hipple and Pagenstecher (1907) treated pregnant dogs with X-rays, using twenty-one Holzknecht units, and produced death and abortion of the embryos or cataracts in the eyes of the young. Krukenberg (1909) found that if the pelvis of a young dog or goat is X-rayed the growth of the hind-legs is retarded; raying the shoulders caused ataxia and nervousness, affected the eyesight,

and made the animal more irritable. Regaud, Nogier and Lacassagne (1912) observed that X-ray exposure led to abortion in dogs. Bagg (1921) observed, following the insertion of small doses of infiltrated radium emanation in the normal brain of the dog and monkey, a pronounced leucocytic infiltration and a marked localized reaction. Warren and Whipple (1922) showed that the intestinal epithelium of the dog is extremely sensitive to the rays, while the liver and pancreas do not seem to be injured.

THE ACTION OF X-RAYS ON THE NORMAL TISSUES OF THE BODY

It was not long after the X-rays began to be generally used by the profession that reports were made of their deleterious action upon the various tissues of the body. Warthin (1906) stated that cases of disturbance of the general condition of the body after irradiation had been reported by Freund (1901), Gocht, Oudin, Sequy and Quenisset (1897), Walsh (1897), Kienbock (1901), Baermann and Linsen (1904), Holzknecht (1902) and others. " These general disturbances may be grouped together as fever, headache, dizziness, insomnia, restlessness, cardiac palpitation and irregularity, gastric pain, and other symptoms. The analgesic effects in certain cases may also be classed here." Warthin regarded these as symptoms of intoxication. Other investigators have made similar observations. Thus, nausea, vomiting, weakness and diarrhœa have frequently been observed after exposure to large doses of hard röntgen-rays. Baermann and Linsen (1904) have described an increased elimination of nitrogen after severe exposure to the X-rays, and Warthin (1907) described changes in the kidneys of patients treated with X-rays. Beckton and Russ (1911) have shown that when certain normal tissues are exposed to the action of α-rays from radium emanation for twenty-four hours the Altmann granules disappear, but the β- and γ-rays acting for the same period have no such effect. Von Jagic (1911) noted varying degrees of lymphocytosis following exposure to the rays. Hall and Whipple (1919) demonstrated an increased nitrogen metabolism and at times a high blood non-protein nitrogen level after irradiation. They also found evidence that the intestinal epithelium is seriously injured by the X-rays in large dose, while Miller (1922) described a condition of protein shock following exposure to the rays.

The very recent investigations of Dodds and Webster (1924) upon the metabolic changes induced in man by the radiation toxæmia following X-ray and radium treatment substantiate remarkably the results obtained experimentally in animals. They found that the changes in metabolism vary essentially with the site irradiated. Thus, radiation of the head, thorax, or limbs produces no appreciable changes in metabolism. Radiation of the cervical region causes an immediate fall in the urinary creatinin due, probably, to a temporary paralysis of the parathyroids. Radiation of the abdomen and spleen produces definite urinary and blood changes. There results a temporary inhibition of the functions of the liver, pancreas, and kidneys. The findings of these observers give some support to Lange's theory of acidosis in radiation toxæmia, in view of the fact that the ammonia coefficient definitely rises as a result of radiation. Accordingly, to prevent these changes, Dodds and Webster suggest the administration of calcium chloride or sodium bicarbonate before radiation.

The Living Cell.—The resisting power of living cells to the action of the X-rays varies greatly. According to Degrais (1914), the " value of resistance " of a perfectly organized adult cell will be found greater than that of one which is young in evolution, such as a sarcoma-cell; hence, healthy tissues will resist more than sarcomatous or other tissues of lower vitality. Young cells are extremely sensitive to the rays, which act in proportion to the special sensitiveness or the particular receptivity of the cells. Hence, after traversing the entire thickness of healthy tissues without altering them, all penetrating rays act therapeutically upon pathologic cells situated in the deeper regions. From whatever source it emanates every ray that strikes a cell influences that cell. This influence and its resultant cellular modification depend upon (1) the degree of receptivity of the cell, or, in other terms, the peculiar sensitiveness which it offers to the rays; (2) the quantity of rays absorbed in a given time; (3) the special qualities of the individual rays; (4) the time elapsed between the application of the rays and the histologic determinations; and (5) the filtering of the rays by the tissues themselves. It is upon this great sensitiveness of cells that *Bergonié and Tribondeau's law* has been based: " *The sensitiveness of a cell is greatest:* (1) *When*

its reproductive activity is most intense; (2) *when its karyokinetic future is longest;* (3) *when its morphology and its functions are less definitely fixed."* These writers have shown the vulnerability of the cells of the spermatic elements of the testicle to the X-rays.

Bardeen (1910–11), in testing the effect of X-rays on cellular tissue, noted that non-nucleated protoplasm retains for some time the power of sensory-motor response and of simple metabolic activity. The power to digest substances is, however, impaired; the power to secrete substances and the power to repair wounds are reduced; the power to form new chlorophyl granules is lost; and the power of cellular reproduction is destroyed. Greenwood (1913) confirmed Lazarus-Barlow's finding that the effect of exposure to small quantities of radium is to increase the proportion of dividing cells.

The Blood and Blood-making Organs.—Scholz (1902, 1904) and others believe that the X-rays and radium may produce primary changes in the intima of the blood-vessels. Senn (1903), Brown (1904), and Bryant and Crane (1904) claimed remarkable results in the treatment of leukæmia by X-ray irradiation. Baermann and Linsen (1904) found no change in irradiated blood and blood-corpuscles. The irradiation of red corpuscles did not affect the hæmolytic power of hæmolytic sera, nor did it change those not hæmolytic. On the other hand, irradiation of sera caused a decrease of hæmolytic power toward non-irradiated solutions of blood-corpuscles. Grawitz (1904) found a diminished resistance of the leucocytes to hypertonic solutions as the result of X-ray treatment of a case of leukæmia. Joseph and Kurpjuweit (1904) found essential changes in the red corpuscles of the blood from a leukæmic patient exposed *in vitro* for thirty minutes as compared with a control. Warthin (1906) made an interesting experimental study of the effect of the X-rays upon the blood-forming organs. Benjamin, Reuss, Slenka and Schwartz (1906), Aubertin and Beaujard (1908), and Murphy and Norton (1915) have shown that X-rays in the proper amount may increase the number of leucocytes. According to Aubertin and Beaujard, the first effect of the rays on the red blood-corpuscles was a fugacious polynucleosis occurring within three hours of the irradiation. This was succeeded by a lowering leucocytosis—which, in the myelogenous form of leucæmia, results in a partial

disappearance of the myelocytes—and by a diminution of the lymphocytes. They concluded that radiotherapy and radium-therapy augment the red blood-cells rapidly, and this increase is durable. The hemoglobin index increases proportionately. Chambers and Russ (1911) have shown that the polymorphonuclear leucocytes of human blood suffer a reduction in their phagocytic power and are eventually destroyed when exposed to α-rays; also, that the opsonin in normal serum is destroyed by these rays.

Ovaries and Testicles.—The destructive action of X-rays on the sexual organs is well known. It was one of the earliest effects of the rays noted. Halberstaedter (1905) found the ovaries much more sensitive to the rays than the skin, and more so than the testicles. Irradiated ovaries show great reduction in size. Specht (1906) has shown that the primordial follicles of the ovaries are far more susceptible than the older follicles. Béclère (1922) found that it was the destructive action on the ovaries which is the cause of the arrest of uterine hemorrhages.

Skin and Hair.—Marcuse (1896) microscopically examined hair which had been treated by X-rays in a case of alopecia and dermatitis, and found degenerative signs. The root of the hair was fibrillated, the sheath swollen, the characteristic cupping at the base absent, and in the shaft the outlines of structure were entirely gone, the line of the medulla being completely lost. The hairs were unusually clear and shining and showed at intervals deep constrictions. Kibbe (1897) examined microscopically the skin from an X-ray burn. The horny layer showed no change; the epithelial cells of the other layers presented evidences of degeneration, the nuclei undergoing disintegration. The formation of keratohyalin was greatly increased. In the chorion there were evidences of mild inflammation most marked about the hair-follicles. Gilchrist (1897) examined the skin from the fingers of an X-ray dermatitis, which showed a chronic inflammation. The horny layer was thickened, partly detached, and contained a large number of brown pigment-granules in the exfoliating portion. The mucous layer was more pigmented than normal. The vessels in the corium were dilated, and the number of pigment-cells in the upper layers was almost as great as in the skin of a negro. Unna (1898) examined a piece of skin taken from an area several times

exposed to the rays. It showed only slight reddening and pigmentation, but the collagenous tissue no longer reacted normally to certain stains but had become basophile. Unna regarded this change as degenerative in nature. Gassmann (1899) made a microscopic study of a deep X-ray ulcer, and found the upper part of the ulcer to consist of structureless, wholly necrotic, masses and heaps of cocci, while in the deeper layers he found unstained fibrillated masses, nuclear remains, fragments of connective-tissue bundles, and great numbers of leucocytes. Deeper still the tissue gradually became normal. The large vessels of the cutis and subcutis showed degeneration of the intima and muscularis characterized by vacuolization, and to these vessel changes he believed was due the formation of the ulcer. Startin (1900) made a microscopic examination of the hair-roots and sheaths in X-ray alopecia and found a peculiar " drying-up " of the tissues. Lion (1901) studied the changes in irradiated skin and in X-ray ulcers, and described a vacuolization and endothelial proliferation. Pusey (1902) stated that irradiation had been used successfully in reducing secretion of the sweat-glands in man. The mode of action is uncertain. He found that the Malpighian layer of the skin became greatly thickened after exposure to X-rays.

THE ACTION OF X-RAYS ON PATHOLOGIC TISSUE

Jensen's Mouse-tumor or Rat-sarcoma.—Loeb (1902), while studying transplanted sarcoma in the rat, found that irradiation had no effect upon mitosis, the tumors continuing to grow after repeated exposure. Degenerative changes were present in the centre of the growth, but this could not with certainty be ascribed to the action of the rays. Herzog (1902) also treated sarcoma in rats. The skin over the tumors became necrotic, and in one case the growth became converted into a cyst filled with a clear fluid and finally sloughed away leaving a clean surface. Apolant (1904) produced a rapid absorption of mouse-tumors *in vivo* by the application of radium. Beckton (1911) found that in carcinomatous growths occurring in mice, granules were present in the malignant cells in about one-third of the tumors. Marie, Clunet and Lapointe (1912) showed that some of the new characteristics imposed upon mouse-sarcoma when exposed *in vivo* to X-rays were still retained in the sixth generation after the exposure had ceased. Wedd and Russ (1912) found that freshly

excised mouse-tumors, when sufficiently irradiated by X-rays and subsequently inoculated into other mice, did not proliferate. The inhibitory effect was more marked when the irradiation was made by soft (*i.e.*, easily absorbed) rays, than when a very penetrating type was used. Excised tumors irradiated for one hour by the β-rays from radium bromide did not proliferate on transplantation. Histologic examination of irradiated grafts at intervals after inoculation showed that the cells of the parenchyma of the tumor persisted for several days but were eventually replaced by fibrous tissue. Lepper (1913) noted that radiation with β- and γ-rays from radium for a time sufficient to prevent continuous growth did not cause disappearance of the Altmann granules in Jensen mouse-carcinoma. Russ and Chambers (1913) obtained the same results as Wedd and Russ. They found that the irradiated sarcoma-cells may remain in the animal body for more than sixty days before giving evidence of growth.

Carcinoma and Epithelioma.—Shattock (1902), examining a mammary carcinoma treated by X-rays, found no changes attributable to the treatment; while Sequeira (1902) saw in the epithelial cells of an irradiated cancer a lysis of both nucleus and protoplasm and a fatty degeneration; and Pusey (1902) found a peculiar degenerative process in irradiated carcinoma masses, the cells losing their contour and nuclei and becoming a structureless, hyaline mass staining a faint blue with hematoxylin. Mikulicz and Fittig examined a portion of a mammary-gland carcinoma four weeks after the beginning of irradiation and found scarcely a trace of carcinomatous tissue with the exception of a few cells or nuclei arranged in an alveolar manner which were to be interpreted as giant-cells. Beck (1902) reported a colloid degeneration of an irradiated adenocarcinoma, similar changes being found in the skin covering the tumor. He also noted a thickening of the intima of the small vessels due to a new formation of a reticulated fibrous tissue. McCaw (1902) observed a colloid degeneration of the epithelial cells of a primary epithelioma of the soft palate and uvula following the use of the X-rays. Scholz (1902) also observed a degeneration of the cancer-cells in an irradiated skin-carcinoma; and Perthes (1903) noted the microscopic changes in irradiated carcinoma. The cancer-

cells showed degeneration and necrosis, the action upon the connective-tissue cells being much less intense. Exner (1903) found some evidences of an irritation of the connective tissue in cases of irradiated tumors. Stewart (1903) reported fatty degeneration and vacuolization of the epithelial pearls of an epithelioma treated by X-rays. A leucocytic infiltration was also present as well as a great increase of bodies resembling Plimmer's bodies. Ellis (1903) studied microscopically the changes occurring in tumors treated by the rays. He found necrosis of cells and trabeculæ, fatty degeneration, increase of elastic tissue, lymphocytic infiltration, absence of polymorphonuclear leucocytes, and a tendency to the obliteration of vessels by deposits on the intima. Mayo (1903), in carcinoma treated by X-rays, found a large number of leucocytes and dilated vessels. Newcomet (1904) found only slight degenerative changes in the cells of carcinoma treated by X-rays. Bashford (1905) attributed the beneficial effect of radium in the treatment of tumors to the proliferation of the stroma. He regarded the destruction of the tumor-cells as a secondary effect, and produced evidence that the proliferation is associated with hemorrhages from the delicate capillaries of the stroma. Vose and Howe (1905) studied the effect of X-rays in 120 cases of cancer. From the microscopic examination they concluded that cutaneous cancer so treated undergoes a degeneration not peculiar to the treatment or distinguishable from degeneration from other causes. The vascular changes are limited to an endarteritis. A new formation of blood-vessels occurs if healing takes place, as in the process of repair elsewhere. There is an increase of elastic tissue. Mitoses are less abundant after the treatment. Beckton (1911) found that in carcinomata, except those originating in the ovary and thyroid, the malignant cells do not contain granules after irradiation.

Skin-lesions.—Scholz (1902) found that after the use of X-rays slight changes were seen in leprosy and mycosis fungoides. In psoriasis an almost complete disappearance of typical lesions occurred after the irradiation. A peculiar pigmentation of both diseased and sound skin was noted. Veliaminoff (1902) stated that Glebovski made microscopic examinations in cases of lupus and rodent ulcer so treated, and found an increase of fibrous and elastic tissue with a fatty degeneration of the lymphoid and giant-cells; while Pernet

(1902) microscopically examined lupus tissue six months after the treatment and found some disintegration of the collagen, destruction of the greater part of the elastin, disintegration and infiltration of the sweat-glands, absence of the sebaceous glands and hair-follicles, thickening of the blood-vessel walls, and a fibrous change in the upper layers of the corium. Walker (1902) reported a fibromyomatous degeneration of a rodent ulcer healing under X-ray treatment; and Mayou (1902) described changes occurring in rodent ulcer after irradiation, finding inflammation of the corium and vacuolization and necrosis of the epithelioid cells. Perthes (1903) found that irradiation caused a slowing of epithelial regeneration and a delay in cicatrization in granulating wounds. Baermann and Linser (1904) found that the essential changes in lupus tissue after irradiation were an endarteritis and contraction of the blood-vessels with degenerative changes in the connective tissue. The epithelium, they concluded, is not primarily affected.

BIOLOGICAL AND PHYSIOLOGICAL DEDUCTIONS

From a careful review of these laboratory and clinical findings it is possible to arrive at various interesting and suggestive deductions of practical value. Thus, it is proved that bacteria are relatively resistant to the X-rays. The least susceptible organisms are some of the unicellular plants and animals, as *Paramœcia*. The rays possess the power of ionizing certain chemical substances; they also retard the activity of enzymes. They are able to modify the life-processes of both plants and animals, and the sensitiveness to the rays varies with the species of plant or animal treated.

The metabolic activities of protoplasm are not immediately affected by the rays, but all cell-activities are eventually either retarded or completely inhibited. Irregularities in mitosis are produced by them. The morphogenic protoplasmic activities (reparative, reproductive, and evolutionary) show the chief effects of exposure of living things to the action of the rays; the sensory-motor activities apparently are not directly disturbed (Bardeen). Younger cells, and especially embryonic tissues, are more sensitive to the rays than are the more mature tissues.

The rays have a selective action on lymphoid, myeloid and epithelial cells, causing nuclear disintegration, fatty degeneration and

necrosis which may be followed by secondary fibroblastic or endo-thelial proliferation (Warthin). Pigment-cells are stimulated to movement by irradiation. Germ-cells of all kinds and developing blood-cells are readily affected by X-rays. The primordial follicles of ovaries are far more susceptible than the older follicles.

In the adult mammal the epidermis, bone-marrow and generative epithelium of the testicle and ovary are all highly susceptible. Other tissues are secondarily affected through alterations produced in the general metabolism or blood-supply by the injuries produced in the actively reproductive tissue (Bardeen). Changes are frequently noted in the interior of the smaller blood-vessels after irradiation.

Fertilized eggs in the early stages of development are very susceptible to the rays. The viscera and muscle-segments of irra-diated embryos appear to develop normally in shape and size. There is, however, a decided inhibition of growth of the irradiated parts, and, in many substances, of the entire embryo. There is, also, a gradual slowing down of all the processes of differentiation, leading, when the dosage is sufficiently great, to actual cessation and death. The effects of irradiation are never seen immediately after exposure but always at some subsequent time.

There is a tendency toward the establishment in the rayed adult body of a chronic disease characterized by a sluggish repair-process with a tendency to malignant changes in the affected tissues. There is also shown by the intestinal mucosa of man and lower animals a peculiar sensitiveness to the hard and short wave-length X-rays. Functional and anatomic studies show that the kidneys are not harmed by exposure to the rays (McQuarrie and Whipple).

CLINICAL EFFECTS OF IRRADIATION IN OBSTETRIC PRACTICE

As yet but little clinical data have accumulated relative to the action of the X-rays upon the mother and child when employed in pregnancy for diagnostic or therapeutic purposes. We are indebted to Bailey and Bagg (1923), of New York, for valuable information upon this subject. They have collated the reported cases, and have drawn some interesting and instructive conclusions from the evidence thus afforded.

If we compare the results obtained in pregnant animals subjected to the action of X-rays and other penetrating light-rays by numerous

investigators, the conclusion is inevitably forced upon us that there is a positive element of danger from their use which must be taken into consideration. This danger, it would appear, is four-fold in its possibilities: (1) Will the rays, by acting directly upon the ovarian follicles, result in a temporary or permanent sterility on the part of the woman arising from a destruction of the germinal elements? (2) Will these follicles, if not destroyed, be so injured or altered as to result in the development of abnormal offspring showing imperfect or defective growth of the whole or parts of the embryos, or even in the formation of monsters? (3) Will the growing embryo be so damaged as to result in embryonic death and early abortion? (4) Or, finally, will the fœtus, apparently normal at birth, show defects in its postnatal development; or, if the irradiation has occurred in late pregnancy, will it show disturbances of metabolism later in life? These are the obstetric and fetal possibilities which only the accumulation of large numbers of clinical reports can finally determine.

The cases showing unfortunate results of irradiation in pregnancy, as noted by Bailey and Bagg, are as follows:

Clark and Keene (1922), four miscarriages in seven patients, three occurring in one woman; Archangelsky (1923), early abortions in seven cases, histologic examination of the embryos showing destructive changes in the central nervous system; Stacy (1922), three still-born fœtuses and two miscarriages in ten pregnant women; Berkley (1922), a case of infantile X-ray alopecia present at birth; Stettner (1921), an infant, born at term, showing deformity of the ears, eyes and genitals and a general disturbance of coördination, followed at two years of age by abnormality of the mental functions with delayed ossification and retardation of growth sixteen months below normal; Aschenheim (1920), the premature delivery at the eighth month of an imbecile child with microcephalus and nearly complete blindness, in a woman who had been irradiated for uterine myoma during early pregnancy; Werner (1921), twenty-four pregnancies in seventeen women treated by irradiation for menorrhagia and myoma, with nine abortions and three children showing deficiency in weight and height in from six to eight years' time. Bailey and Bagg themselves report the case of a woman irradiated during pregnancy, who gave birth to a child with spina bifida and double club-

foot; another who became pregnant after irradiation for Hodgkins's disease and gave birth to a child with malformation of the head including an open sagittal suture with exposure of the brain; and another who conceived after irradiation for uterine fibroid and was delivered at term of a still-born fœtus.

These authors, from this small number of case reports, conclude that irradiation during early pregnancy may produce death and abortion of the fœtus; and that irradiation during late pregnancy is not so likely to produce gross developmental abnormalities in the child at birth, but may cause retardation of growth subsequent to birth. They believe, therefore, that irradiation of the ovum during early pregnancy should never be permitted, and in later pregnancy should be resorted to with extreme care. These conclusions seem justifiable when the results of the biological experimenters are considered in connection with the limited case reports from clinical practice. These findings, of very recent date, are decidedly at variance with those of Edelberg (1914), ten years before, who believed that the danger of fetal injury from the use of the rays was negligible.

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TREATMENT WITH RADIUM *

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RADIUM may be employed as a salt and the dose expressed as so many milligrams of radium element applied for so many hours; or the product of these two factors, so many milligram hours. Or it may be applied as an emanation collected from a stock solution containing a very large and valuable quantity of radium salt, permanently preserved in a safe and connected with a complicated apparatus of tubes and air-pumps. The strength of the emanation tube or other applicator is measured by comparing its ionizing effect with that of a tube of radium salt. The quantity of radium emanation in equilibrium with one milligram of radium element is called one millicurie and the dose may be so many millicurie hours. For some purposes the emanation tube is left buried in the tissues. The emanation rapidly loses its strength, losing half in 3.65 days and becoming practically inert in a month. For each millicurie left buried in the tissues we calculate that a dose of 130 millicurie hours will be applied, most of it in the first week or two.

For oral or intravenous administration either radium solution kept in sealed glass ampules or freshly prepared emanation solution in water is used. For local application the radium salt or emanation is sometimes enclosed in glass tubes, or in hollow steel needles, or the radium salt may be incorporated in a glass coating on a flat metal applicator, or be coated upon a flat metal applicator and covered by a thin sheet of glass or of metal. Flexible pads saturated with radium emanation are also of value during their period of activity.

RADIUM ADMINISTERED INTERNALLY

The effect of radium administered by the mouth or intravenously is in general to increase metabolism and elimination. It is used by the author in cases, for example, of high arterial tension, arterio-

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* It should be noted all through this article that no effort is made to catalogue the conditions for which radium is used; the omission of any use does not imply a denial thereof.

sclerosis and the arthritic diatheses. Patients with sciatica who have improved only to a limited extent under various dietary, medicinal and electrotherapeutic and phototherapeutic measures have been freed from pain and have ultimately been cured after taking radium or emanation internally. The difficult cases of Dupuytren's contracture are also given this systemic treatment in addition to radium and the X-rays locally, and attention to any focus of infection and to diet. In one case I have had a complete cure and in several others the progress of the disease has been arrested. (Fig. 1.)

If I give the radium itself it is in ampules containing 2 micrograms given once a day. The emanation water should be 5000 Mache units a day or more, depending upon the age and weight of the patient.

An indication for an intermission in the treatment, even if more is to be given, is the appearance of small, red, slightly scaly spots with little if any itching.

The *local application of radium* has effects which vary with the quantity of radium or of the emanation employed, the amount of filtration determining the percentage of rays of but little penetration which are consequently readily absorbed by the surface tissues; and the distance and length of time.

The radium operator must not only have an extensive armamentarium, but has to have a very special knowledge of dosage under many different conditions.

APPLIED FOR A SURFACE EFFECT

As an example, 20 milligrams of radium salt containing 11 milligrams of radium element in a sealed glass tube applied for thirty minutes will cause a superficial destruction of any tissue with a cure of such a condition as a wart, including the troublesome subungual warts (Fig. 2), or a cure of a corn or a mole. Such an application to an epithelioma causes destruction, and the growth usually changes into a scab which comes away in a month, leaving a healed surface and as a rule with a permanent cure. (Figs. 3, 4, 5, 6, and 7.) This is never promised, however. One or more additional applications are better than to make a single excessive one. The keratoses on the hands and face of X-ray operators were first treated by radium by the present author. My own hands were in a dangerous condition in November, 1914, in spite of some terribly painful treatments by

Fig. 1.

Dupuytren's contraction; arrested by radium.

Fig. 2.
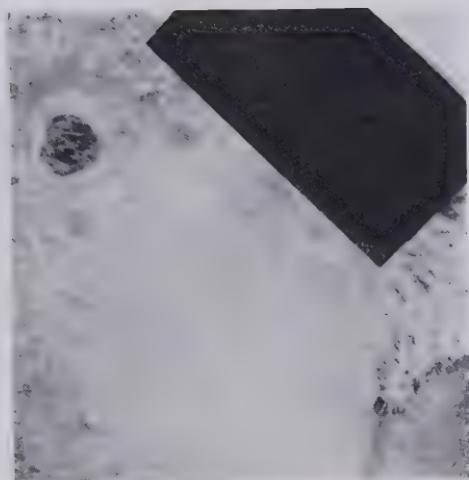

Subungual wart before cure by radium.

Fig. 3.

Mrs. McL., April 14, 1920, before treatment of keratosis (precancerous) of forehead.

Fig. 4.

Mrs. McL., January 3, 1921, after cure by treatment with radium.

FIG. 5.

Epithelioma of face before cure by radium.

FIG. 6.

Patient with epithelioma; one of the few cases where the application of radium has failed.
(See Fig. 10.)

FIG 7.

The same patient as seen in Fig. 9. There has been an extension of the epithelioma in spite of the application of radium and all other forms of treatment, with final loss of the eye.

FIG. 8.

Treatment of vernal conjunctivitis by radium. A metal shield is between the eyelids and the eyeball, protecting the latter. The radium tube is held against the inner surface of the upper eyelid everted by a special instrument.

pyrogallic and other acids. All my friends among the earliest workers with the X-ray were either dead or had lesions which were manifestly going to prove fatal. Amputation had proved unsuccessful in the case of other sufferers. The author was curing conditions every day which actually were cancer and it suddenly occurred to me to try radium for these lesions which were not yet cancer. The natures of X-rays and radium are so similar that there seemed a possibility that radium would only aggravate the trouble, but I knew just how to produce a certain effect upon the tissues, and while it was an experiment which I would not have tried upon a patient I did try it on myself. The first place was about half an inch in diameter and about one-quarter inch in thickness, covering the proximal interphalangeal articulation of the left ring finger. Only one slight additional application has been necessary there in all these ten years, but of course for numerous other places I have had to take about forty radium treatments. I am sure these treatments have saved my life and the lives of many other X-ray workers.

All these are examples of conditions in which the effect desired is a superficial destruction of tissue which gradually follows the application, while the deeper tissues are cured of the lesion and usually healed before the dry scab comes off. The radiation is limited to the desired area by means of a sheet of lead at least one-sixteenth inch thick with a suitable opening or " window." The same surface effect may be obtained by laying upon the surface a radium needle or a number of radium needles about one-quarter inch apart. Radium placques for surface application are more convenient than either tubes or needles and produce a more uniform effect. A similar application to an ulcerated or to a mucous surface does not usually produce necrosis and a slough or a scab but simply a gradual cleaning and healing of the surface with a cure of the lesion. An example is a case of ulcer of the anterior vaginal wall which had failed to be cured by applications such as nitrate of silver, and which seemed to be doubtless malignant. Others are the many cases of vernal conjunctivitis referred to the author for treatment. (Fig 8.) In these a growth resembling granulation tissue persists on the inner surface of the upper eyelid for years in spite of caustics and other applications and even surgical removal. One radium application often affects a per-

manent cure and seldom are more than two required. Still another example is a corn. And I do not know where I have given more relief than in the cases in which a corn has become so inflamed that the patient begged the surgeon to amputate the toe. The pain and redness and swelling begin to subside immediately. The corn has been pared down as far as practicable before the application, but for a while additional paring is desirable twice a week. In about two weeks the corn has ceased to grow and the toe is of normal size and free from pain, redness and swelling. I always prefer to make the radium application surely not excessive in these cases so that more often than not a second application is required. The result is that without any pain from the treatment the corn entirely disappears, leaving normal skin. Of course there is nothing to prevent the patient from cultivating a new corn in the course of a few years by wearing shoes that press upon that spot; but this can be avoided. I believe that mankind would be better off if every corn were treated in this way, not merely the desperate cases which now resort to radium. But the imperativeness of proper dosage and technic make it a treatment which I should only recommend to the radium specialist.

Small skin areas of eczema or those similar to psoriasis are readily cured by these surface applications of radium.

Painful fissures without any tendency to heal, at the anus or elsewhere, have the pain relieved at once and are converted into a crust which comes off leaving a healed surface. Some nævi, including most of the hairy moles, are suited to this treatment and are cured by being converted into a dry crust.

The dosage for all the above cases is varied according to the exact thickness of the tissues which it is desired to convert into a crust and also by the extent to which it is desirable to affect the deeper layers. The application of the unscreened glass tube containing 20 milligrams of salt for thirty minutes is almost too much for many cases because of the possibility of ulceration and subsequent scarring and telangiectasis; but there are cases where this dose is correct or has to be exceeded. Thirty minutes or a little less through the thinnest rubber dam is a very usual dose for the cases described. For an old lady with multiple epitheliomata of the face, one of which failed to heal after such a treatment but presented an appearance of a flat

granulation surface, I made an application of forty minutes with the thinnest rubber dam, supplemented at the same session by one hour with an aluminum filter. The reaction was severe but the lesion was permanently cured without noticeable scarring. This is really an example of a combination of the superficial destruction by radium (beta rays) which has been the subject of the first part of this paper and the deeper effect with an alterative instead of a necrotic effect, which we are now to discuss.

DEEP EFFECT FROM RADIUM WITHOUT NECROSIS AND USUALLY WITHOUT DERMATITIS

The gamma rays constitute about one-hundredth of the total radiation from radium, but about 90 per cent. of this total is alpha particles which never get through the glass walls of the tube or the steel of the needle or the protective surface of the placque. So the gamma rays constitute about one-tenth of the effective radiation from our radium. The beta rays whose utility has been described above are very readily absorbed and produce a very active surface effect. The gamma rays are very penetrating; for instance, viewed with a fluoroscope there is only a slight reduction in intensity by interposing one-quarter inch of lead. These are the rays which enable us to make a picture through a paving stone. When we are applying the beta rays for a surface effect we are also applying one-tenth of that amount of the penetrating (gamma) rays which do no harm but add a little to the beneficial effect, especially in the direction of preventing a recurrence of the lesion. But if we applied radiation comprising nine parts of surface affecting (beta) rays and only one part of penetrating (gamma) rays the greatest dose that the skin would stand without a serious radium burn would afford much less than the required effect in deep lesions. A suitable filter arresting practically all of the surface (beta) rays while scarcely affecting the penetrating (gamma) rays enables us to apply the latter in such dosage as to secure all the deep effect desired and usually without even reddening the skin.

As an example of dosage, a patient of the author's has a supraclavicular glandular mass, recurring after an operation for breast cancer. (Fig. 9.) Fifty milligrams of radium element distributed over an area of 2 square inches and filtered by 0.4 mm. steel; 1 mm. brass, and 16 mm. felt were applied for a total of six hours in the course of

a few weeks. This was in addition to general X-raying of that side of the chest. The glandular mass has decreased in size and the patient's health has improved, but the condition, of course, is very grave. Carcinoma of the chest wall, recurrent after operation for cancer of the breast, and not only visible and palpable, but showing in the radiograph, has been the subject of my treatment in many cases. One of these patients shows in radiographs of three years ago and also at the present time (but reduced by treatment) an intrathoracic growth in addition to one of the chest wall. She first came to me for post-operative X-ray and radium treatment eight years ago, and this treatment combined with recent surgical removal of a small nodule has kept her feeling and looking perfectly well.

These are cases in which a combination of radium and X-rays is necessary. I find radium better where the tissue to be affected is in contact with the instrument or not more than $1\frac{1}{2}$ inches from it; but for tissues beyond that distance the X-ray is the only thing and especially the recently developed X-rays corresponding to high but not to the most extremely high voltage.

For a cancer of the tongue in a man of seventy-two years with a negative Wassermann and no sign of tuberculosis the treatment was inaugurated by burying 50 milligrams of radium element in four steel needles. (Fig. 10.) These formed a square an inch on the side at a depth of one-quarter inch below the surface of the ulcer and were left in place two hours, and again two hours six weeks later. Other applications to various parts of the inside of the mouth were made with all four 12.5-milligram needles in a brass capsule (1 mm.) surrounded by 8 mm. felt and left in place two hours at a time. A 50-milligram placque with the same screening was applied for two hours under the chin and over the submaxillary glands on each side. A regular routine was followed in accordance with which every area received six hours' treatment in the course of six or eight weeks. This was followed up by deep X-ray therapy applied to both submaxillary regions, the mediastinum, the epigastrium and the pelvis. The hope was to prevent metastasis or to abort it if it had already occurred. The effect was that the ulcer which had apparently destroyed the right half of the tongue was healed in three months and the loss of substance seems to have been renewed because now, a year and eight months later, the

Fig. 9.

Carcinoma of breast; recurrence in the supraclavicular glands; benefited by radium.

Fig. 10.
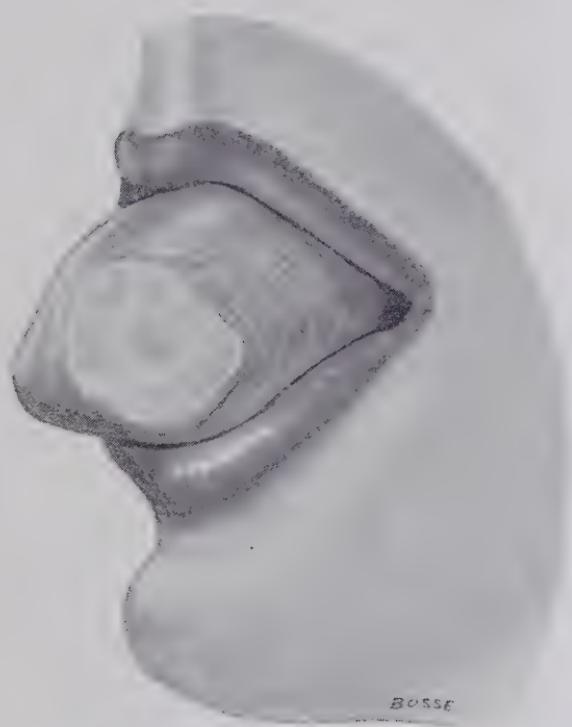
Cancer of the tongue before radium and X-ray treatment. Wassermann negative. Healed in three months; remaining well at present writing twenty months later.

Fig. 11.

Ulcer of the tongue, supposedly tubercular, before cure by radium.

Fig. 12.

Cavernous angioma of labium major before cure by radium.

tongue has the natural shape, size and motility. The place of the ulcer is covered by mucous membrane a little smoother than elsewhere. A prophylactic course of treatment was given at the end of six months and again at the end of a year. The patient seems perfectly well.

Another patient, a man about thirty-four years of age, had a severe ulceration of the tongue with the appearance of malignancy. A Wassermann test was negative, but the subsequent development of tuberculosis caused one to suppose that the lesion of the tongue was also tuberculous. (Fig. 11.) After proper applications of radium to the surface the ulcer took on the appearance of wet wash leather, which disappeared gradually, leaving a healed and cured surface. Beginning June 14, 1922, 50 mg. radium element filtered by 0.4 mm. steel, 1 mm. brass and the thinnest rubber dam was applied for a total of $9\frac{1}{2}$ hours, distributed over an area of about two square inches in about two weeks. At the present writing, two years later, the tongue is perfectly well.

A remarkable case showing the deep effect of radium without a surface effect illustrates the fact that there is a cumulative effect from repeated radium applications just as there is from the X-ray. My idea of dosage with both of these agents is that there are cases which cannot be cured by a single application. And in these cases I give a series of applications so measured and so timed that the healthy cells recover from one application before the next one is given; and the more susceptible morbid cells still remain under the influence of the previous application when the next is given and adds its effect to the effect of those that have gone before. The patient referred to was considered by Dr. George Houston Bell and the other attending surgeons at the New York Eye and Ear Infirmary as sarcoma of the orbit, the diagnosis being based on the X-ray appearance as well as upon the history and physical signs. When she was referred to me the tumor seemed the size of an orange. The eyelids, eyebrows, and skin of the temporal region were tightly stretched over it and presented a shining dark red surface. The opening in the eyelids was the natural size and there could be seen the deformed and damaged eyeball, apparently two or three inches out of the socket. The whole thing was a ghastly spectacle. Treatments were given once a week for ten weeks. Each one consisted in one hour's application of a

glass tube containing 20 mg. of radium salt (10.5 mg. of radium element) filtered by 1 mm. aluminum and 1 mm. lead and 1 mm. soft rubber. The first application was to an area corresponding to the outer part of the upper eyelid, and the next to the inner part of the upper eyelid. The subsequent applications were to parts corresponding to the outer and inner parts of the eyebrow and to two parts of the frontotemporal region. Six areas, each an inch and a half from any other, received these applications. Two weeks after the first treatment the surface of the tumor looked less red and shiny and was shriveled like an apple that has begun to dry. The patient said she could see a reduction in size. In a very few weeks this was perfectly manifest and at a certain stage all that remained was hard and smooth and the size of a marble in the orbit. A week later, ten weeks after beginning treatment, not a trace of the tumor remained. No further treatment was given. Five weeks after the last treatment the patient sat on the platform at the Ophthalmological Section of the New York Academy of Medicine with an artificial eye, there had been an evisceration, not an enucleation, for fear of exciting metastasis. The patient presented a normal appearance, which has continued so for the four years that have passed. There was never any skin reaction; in fact the skin which had been red became white and normal during the course of treatment. In this case the tumor received not only a cumulative effect from the repeated applications of penetrating rays but also a cross-fire from six different directions, which was much more effective than if the tumor had been so situated that we could only apply the amount of radiation endurable by a single area of application. (*Arch. of Ophthalmology,* vol. xlviii, No. 6.)

Some cases of inoperable, usually recurrent, cancer of the breast require a similar effect of gradual disappearance of the tumor without necrosis; and here it is best accomplished by imbedding radium needles 1 cm. apart, for four hours if each needle contains 10 mg., or a little over three hours if each contains 12.5 mg. I have seen the late Dr. Russell H. Boggs imbed twenty-six radium needles in a single cancer. A case of epithelioma of the face with quite deep induration seemed to me to require the same treatment and two radium needles transfixed it, parallel with each other and 1 cm. apart. They were left in place two and one-half hours and this application

was supplemented by filtered surface applications of 50 mg. of radium to the growth for a total of four hours and deep X-raying of the neighboring and distant glandular regions. The growth disappeared without crusting or ulceration.

A patient after being radiographed was operated on for the removal of carcinoma of the ovary, the appendix being also removed. A few years later she developed a palpable tumor in the right iliac region for which I made an X-ray examination. She suffered from vomiting and almost complete obstruction of the bowels, and was able to take only soups strained through a cambric handkerchief. Practically the only abnormal X-ray appearance was in the region of the cæcum and ascending colon which had a curious double-barreled appearance. My diagnosis was a tumor outside the intestine but pressing upon it. I advised an operation without opening the intestine, and radium and X-ray treatment as a prophylactic against recurrence. The tumor was found to be of a gelatinous consistency. The radiation was not resorted to until a recurrence of the tumor and of all the original symptoms had taken place. At each treatment with radium 20 milligrams of salt in a glass tube filtered by aluminum and lead and soft rubber was placed for an hour at each of three parts of the periphery of the tumor. A regulation hard-rubber bowling ball was laid on top for compression, so that the radium was closely in contact with the tumor except for the thin abdominal wall, which presented scarcely any obstruction to the gamma rays. Such a treatment was given about once a month and between times the X-ray was applied to the abdomen, front and back and at the sides. The tumor disappeared and so did all the symptoms, eating and the action of the bowels becoming normal. At one time the peritoneal cavity filled with the same gelatinous substance which really had to be spooned out through an incision, not drained off through a puncture. These various treatments by operation and radiation kept the patient comparatively well for eleven years after the first operation for cancer; she died rather quickly with pain and vomiting.

A very important use of radium is as an antiseptic and is perhaps original with the author. A severe crushing injury of the wrist was accompanied by infection with *Bacillus pyocyaneus,* demonstrated by

culture as well as diagnosed from the blue pus. The surgeon referred the case as a last resort although expressing belief in the probable necessity for amputation. Treatment was by radium placque containing 50 mg. of radium screened by 0.4 mm. steel, 1 mm. brass and 8 mm. felt, applied on eight occasions in three weeks. The applications were at three different aspects of the wrist-joint, only every third one being at the suppurating sinus on the dorsum. The others were palmo-ulnar and palmo-radial. Suppuration soon ceased and when the three weeks had elapsed the patient seemed to be cured. The total time of application was two and one-quarter hours.

Neuroma or a localized neuritis has sometimes been referred to me for treatment. One produced a visible and palpable and very tender swelling of the palmar surface of the index finger of an oculist. Another was a painful as well as tender swelling of the ulnar nerve where it could be palpated behind the elbow in a clergyman. In neither was there anything in the history to account for the lesion; and in both the treatment was the same: 20 mg. of radium salt equal to 10.5 mg. of radium element filtered by the glass of the tube by 1 mm. aluminum, 1 mm. of lead, and thin rubber dam. Each application lasted an hour. Only one treatment was required for the finger and the lesion has left the distal part of the finger with lessened tactile sensation. Several treatments at intervals of about three weeks were required for the ulnar nerve, which was entirely cured without any sequelæ. There was no effect upon the skin at any time in either case.

The author's treatment of tonsils depends upon the nature of the case. A young lady, who had a tonsillectomy performed many years previously and was constantly under the care of a throat and nose specialist for infection in the remnants and always suffered from rheumatism and neuritis regarded as secondary to tonsillar infection, was finally advised by the rhinologist to have an enucleation performed. A consulting internist did not think this advisable and she was referred to me. An excellent treatment for such a case is by the application of the X-rays externally, and this was followed by complete cure. " The throat is as flat as a pancake," the patient reported three or four years later. The regular enlarged and occasionally

infected tonsils which would formerly have been operated upon are very desirably treated by imbedding a 10-milligram radium needle in each for two or three hours, depending upon the size of the tonsil, or a 50-milligram placque with 0.4 mm. steel, 1 mm. brass and 1 inch of felt may be applied externally, near the angle of the jaw, for a total of twelve hours on each side. This has proven very successful in the author's practice. A less convenient application is to the surface of the tonsils inside the mouth, 50 to 150 milligram hours to each tonsil with 1 mm. brass and 3 mm. felt screen. Having a capillary tube of radium emanation permanently buried in each tonsil is a wonderfully easy and expeditious way of applying radium. The amount of emanation in each tube must be very small. Each millicurie loses half its strength every four days and in that time applies 48 millicurie hours or as great a dose as a 10-milligram needle left in place for five hours. And another 48 millicurie hours is applied by the one millicurie " seed," as they are called, in the next four weeks. Accordingly the most desirable dose of radium emanation is $\frac{1}{3}$ millicurie imbedded in each tonsil. A larger amount such as 0.6 in one and 0.8 millicurie in the other tonsil will produce a wonderfully fine effect in causing the disappearance of the tonsils at the end of two weeks; but for a long time afterward there is very great suffering and it is many months before any comfort is obtained. The final result is no better than with the smaller dose followed by a gradual disappearance of lymphoid tissue and infection.

This is mentioned as an example, and there are many others, of the necessity for proper dosage in radium treatment.

Radium in cancer of the larynx is of the greatest utility. It has, like the X-ray, the property of causing inflammation of the laryngeal articulations and a preliminary tracheotomy is always desirable to guard against laryngeal obstruction. A man, with an undoubted recurrence of carcinoma after excision of the larynx, was treated by the author with marked reduction in the size of the tumor, improvement in swallowing which had been reduced to clear soup filtered through a cambric handkerchief, and even ability to talk in a loud whisper with the tracheotomy opening closed with the finger. This local improvement was maintained, but about a year later the patient died with symptoms indicative of cancer of the liver or stomach.

Radium treatment of nevus and telangiectasis in general accomplishes marvelous results. The nature of the cases enables us to choose the kind of application and effect that will be most beneficial. The pigmented hairy nevus is usually destroyed by a single surface application of the 20-milligram tube of radium salt and for from eighteen to thirty minutes. A dry scab forms which leaves a normal surface. Little surface marks consisting of dilated arterioles are treated in the same way. The case illustrated was of a very different character. A baby was born with a flat red spot on the labium major which

Fig. 13.

Author's method of applying radium to the labium major in
a case of cavernous angioma. (See Fig. 12)

extended rapidly, not only on the surface but in the deeper tissues. At the age of ten weeks that side of the vulva consisted of a large vascular tumor the surface of which presented a deep ulceration. Treatment was by applying 10.5 milligrams of radium in a glass tube screened by 1 mm. aluminum and thin rubber dam for an hour at each of two parts of the tumor. Treatments were about three weeks apart and inside of two weeks after the first application decided improvement was seen. And after the third treatment a normal condition seemed to have been brought about, that labium looking the same as the other. There was no skin reaction from the radium applications, which were never repeated at the same place. (Figs. 12 and 13.)

Keloid as a local lesion is successfully treated by radium, but of course it usually implies a constitutional tendency. For this the author many years ago discovered that thiosinamin internally was a cure. This takes months of administration and in the meanwhile radium can be applied locally. A good many of the cases referred to the author have keloid of the face developing in a scar following an operation for the removal of paraffin injected for beautifying purposes. Others have developed in a burn. A puzzling case was that of a lady who for a dozen years had had her face skinned every three years, and always, she said, with satisfactory results until the last occasion. At that time, just when the chin was in the most tender condition, she had a bilious attack for which she took mustard as an emetic. Some mustard got on her chin and made a burn, which left a dreadful scar across her chin. In this keloid developed and this was successfully treated by another radium operator. The fibrous induration disappeared and only the broad white shiny scar from the burn remained. This was such a disfigurement, however, that she was sent to me for treatment. My efforts have been to vascularize and repigmentize the scar tissue. Applications of the mercury vapor quartz lamp, air-cooled, and of diathermy have made an improvement over which the patient is wildly enthusiastic, although the scar is still visible. The diathermy was applied by connecting the patient's wrists with the two terminals of a high-frequency apparatus. If the patient should then touch the terminals of an electric bulb with the forefinger of each hand the bulb would light up brilliantly. The same kind of current is applied to the scar and other parts of the face by the patient's own fingers.

Radium applications to keloid are not of a nature to turn the lesion into a scab and cause it to fall off, very probably with recurrence of the keloid, but they are of an alterative character, usually without any surface reaction. So a screened applicator is employed, using the gamma and the more penetrating beta rays, but not the rays that would be absorbed by the outer layers of the skin. A suitable applicator is 20 milligrams of radium salt in glass and in an aluminum treatment tube, and 1 mm. of lead and 1 mm. of soft rubber for an hour. This may have to be repeated at intervals of a month or two.

Dupuytren's contraction has been cured by the author in one case and in several others has been arrested by radium applications on the same plan as for keloid. Of course diet and attention to teeth and other foci of infection received attention.

Radium in gynæcology has been the subject of a monograph by the author and is dismissed with these few words because it would require more space than is available here to do justice to its importance.

RADIATION IN MENOPAUSAL DISTURBANCES

The author believes this to be original with him. By the employment of moderate doses of radium and the X-ray, menstruation may be brought to an end. And in the author's cases there have been none of the mental and nervous disturbances characteristic of menopause after removal of the ovaries. The treatment by radiation brings ovarian function to an end as far as concerns menstruation and child-bearing, without interference with the internal secretions which give the distinctly feminine appearance and characteristics. And in the author's cases there have been normal marital relations and enjoyment. The relief from high blood-pressure and intense nervousness and cardiac palpitation make the treatment a blessing aside from the cure of a possible co-existent fibroid with its dreadful hemorrhages. The treatment has also great value as a prophylactic against cancer.

Diagnosis and Treatment

CAUDAL ANÆSTHESIA IN UROLOGY: A NEW METHOD FOR LOCATING THE SACRAL HIATUS

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THE urologist, more than any other specialist, is in need of an anæsthesia which will not further embarrass, in most instances, the work of damaged kidneys and will permit urological examinations and operations, without risk or discomfort to the patient, which are occasioned by the methods more commonly employed. This we believe is found in caudal block, which we offer with some hesitancy, due to the small amount of clinical evidence submitted, but with the hope of inspiring others to try out this method, which we believe to be a valuable asset in urology, especially on account of the ease with which it may be performed.

HISTORY

The extradural administration of anæsthetics was first done by Cathelin, in 1900. He injected a solution of cocaine into the sacral canal of dogs, suspended them by their hind legs and was able to produce profound anæsthesia. The direct result of this work was the introduction in France of the epidural medication to the nerves of the sacral canal in sciatica. Discovery of the non-toxic drugs gave a new impetus to nerve blocking and the method was revived by Stoeckel in 1909, who used a novocaine solution, in the sacral canal in obstetrics. One year later it was introduced into urology, by Lowen and Gros, who used it in perineal and urethral operations. In 1916 Lewis and Bartels, of the Leipzig clinic, reported sixty-eight cystoscopies and other procedures by the method. It was intro-

duced in the Mayo clinic in 1920 by Gaston Labat, from Pauchet's clinic in Paris, who demonstrated that satisfactory anæsthesia could be obtained for various urological manipulations and operations.

ANATOMY

To obtain satisfactory anæsthesia by epidural injection, a thorough knowledge of the anatomy of the sacrum and pelvic landmarks

Fig. 1.

Cross-section of the sacrum, showing the canal.

is necessary. The sacrum is made up of the five sacral vertebræ which fuse about the fifteenth year of life. The fourth and fifth, however, fail to completely unite posteriorly, leaving a triangular opening at the lower end which is covered by a membrane. This space is known as the sacral hiatus and is bound laterally by the cornua and above by the fourth spine and may be felt as a depression within these limits. (Figs. 1 and 2.)

The sacral canal is admirably adapted to the procedure of nerve blocking, because all the sacral foramina open into it, any fluid injected will reach the nerves. Its entire length is from 6 to 9 cm., the dura ending between the first and second segments, consequently a needle can usually be introduced longitudinally about 5 cm. without entering the spinal canal. (Fig. 3.)

METHOD

The method for locating the sacral hiatus is described by all writers substantially as follows: Place the patient on the abdomen

FIG. 2.
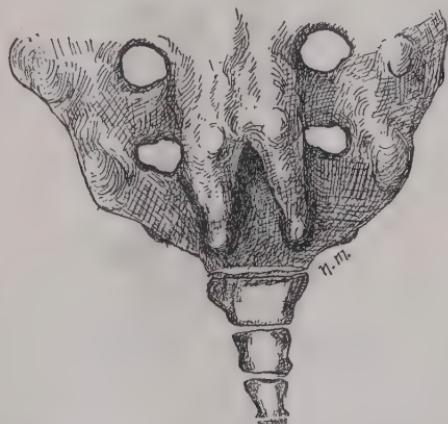
Drawing of sacral hiatus and cornua with coccyx attached.

and locate by palpation, the fourth sacral spine and the cornua of the sacrum. The centre of the triangular area thus outlined is the proper point at which to introduce the needle. It is often difficult to locate this area, especially for a beginner, on account of the landmarks not being readily appreciable on palpation, due to many variations of the opening; which we believe were responsible for our failures in the beginning of this work at the St. Agnes Hospital. This led us to further investigations, which gave us a suggestion from Mr. E. F. Faber, medical art instructor of the University of Pennsylvania, that we take an easily located landmark and work out a method of finding from this point the centre of the hiatus.

By making measurements on articulated skeletons, we soon discovered that in practically all instances, the distance between the

posterior superior spines of the ileum was the same as from either of the spines to the centre of the hiatus. In other words, the spines of the ileum and the centre of the hiatus marked the angles of an equilateral triangle. Since we could not find anywhere in the literature a record of similar observations, we made a total of 170 corroborative examinations, which are tabulated as follows: Sixty-five

FIG. 3.
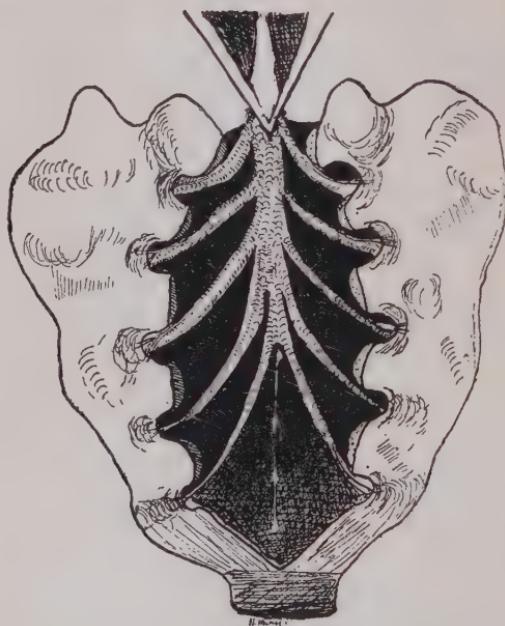
Showing the top of the sacrum removed and the termination of the dura, with the sacral nerves exposed.

ambulatory patients, from the clinics of three different hospitals; eighty-two articulated pelves, in the anatomical department of the University of Pennsylvania and the Mütter museum; twenty-three cadavers in the dissecting room of the graduate school of medicine. Of the articulated pelves examined, only seventeen were normal, the remaining sixty-five being abnormal, yet the measurements were constant in seventy-one instances and varied in only eleven pelves, these being all of the deformed type. Skeletons of all sizes were examined, ranging from that of a full-term infant, which measured one inch between the posterior spines of the ileum, to that of the Kentucky giant, which measured five and one-half inches between the same

FIG. 4.
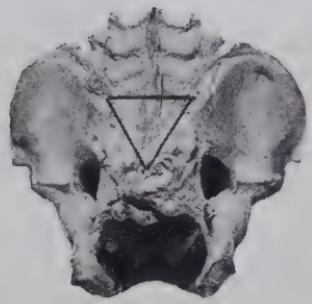
Equilateral triangle on the pelvis of a full-term baby, with apex over the small hiatus.

FIG. 5.
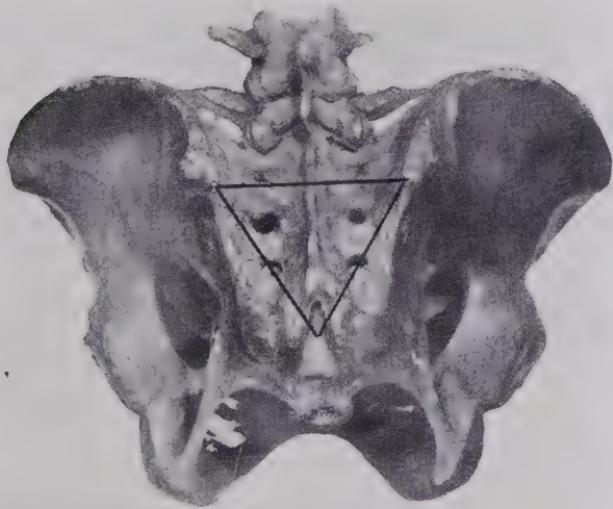
This female pelvis, from the collection of the late John M. Keating, M.D., was chosen for the measurements on account of its accuracy of form. While making these investigations, the equilateral triangle for locating the sacral hiatus was discovered.

Fig. 6.   Fig. 7.   Fig. 8.

Normal sacra, with their sacral hiatuses opening about normally.

Fig. 9.

The two dimples show where the right and left posterior superior spines are located, the distance between them being the base of an equilateral triangle.

Fig. 10.
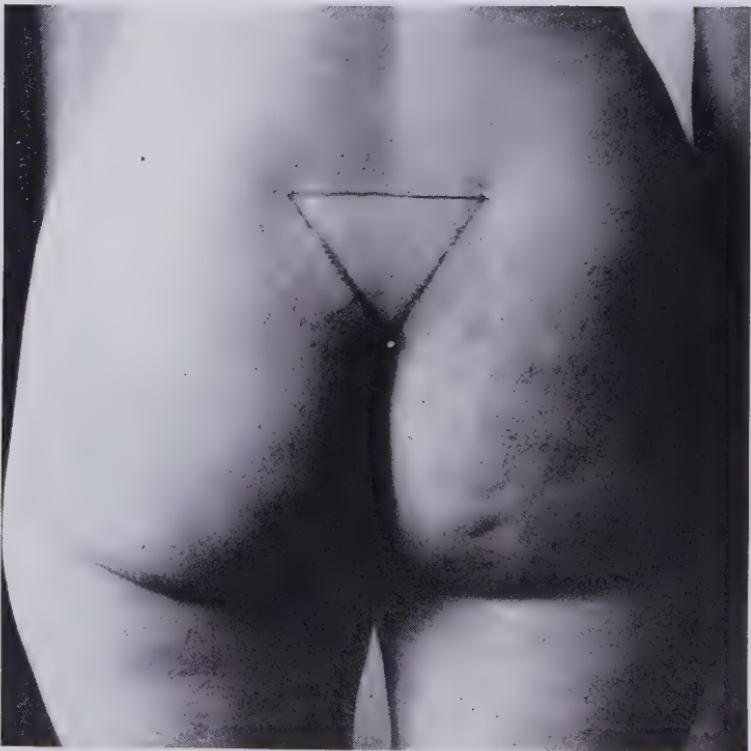
Equilateral triangle drawn on the female shown in Fig. 9, the spines having first been connected, and the point over the sacral hiatus having been later located by the completion of an equilateral triangle.

Fig. 11.

The needle is inserted through the skin and sacrococcygeal membrane at the apex of the triangle at an angle of 10 degrees, in order to enter the hiatus.

Fig. 12

Needle being introduced into the sacral canal at an angle of 45 degrees.

points.   All examinations on the ambulatory patients, so far as we could determine, were confirmative of our conclusions, and the same was true of those made on the cadavers, where we were able to confirm the accuracy of the method by introducing the needle and making incisions in all cases.   (Figs. 4, 5, 6, 7 and 8.)

The method of locating the sacral hiatus is very easily applied. The posterior superior spines of the ileum are readily located by palpation, and by the dimpling, which nearly always shows at these two points.   (Fig. 9.)   With a rule the distance between the two spines is determined, then a line drawn the same distance, from each spine toward the tip of the coccyx, meets its fellow, over the centre of the hiatus.   (Fig. 10.)   This may be more accurately done by placing the points of pencil calipers over each spine, then describing from them toward the coccyx.   The intersection of the two arcs will mark the desired point.   This should be verified, if possible, by palpation, which gives a double assurance of locating the opening.

TECHNIC

Before attempting to introduce the needle, the patient should be placed on his abdomen, with a pillow under his hips.   This elevation of the pelvis helps to bring out the bony landmarks and also aids in the diffusion of the anæsthetic.   The proper point for introduction of the needle being located, the field should be well cleansed with alcohol and the site of puncture infiltrated with a 1 per cent. solution of novocaine, which makes the method a painless procedure. An 18- or 20-gauge spinal puncture needle, which will fit a Leur syringe, is then introduced, with the stylet in place, through the skin and all the tissues, at an angle of forty-five degrees, until it comes in contact with bone.   (Figs. 11, 12, 13 and 14.)   The needle is slightly withdrawn, and the end depressed to an angle of twenty degrees, it is then slowly and carefully introduced upward in the midline.   If the technic is correct there is a sensation, plainly discernible, of the needle passing into a free cavity.   The beginner may imagine he has passed it into an open space.   After the needle has been pushed in from one and a half to two inches, or about 5 centimetres, the stylet is withdrawn and aspiration is made, to see if the spinal canal or a blood-vessel has been entered.   If this has happened, withdraw the needle until the flow stops; then inject slowly under constant

pressure, 60 c.c. of a freshly prepared 1 per cent. novocaine solution, which may be done with a 20 or 30 c.c. Leur syringe.

DISTRIBUTION OF ANÆSTHESIA

From our experience we believe that the area of anæsthesia depends on the amount of solution injected, which will be given in detailed case reports. Brenner has shown that 20 c.c. of a methylene blue solution, injected into the sacral canal of a cadaver, bathed the second, third, fourth and fifth sacral nerves; 30 c.c. filled the canal

FIG. 13.
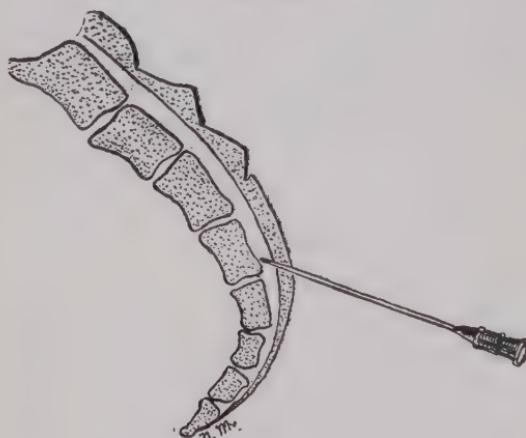
Drawing of sagittal section of sacrum, with needle inserted.

under slight tension, and the fluid passed out 3 centimetres along the nerve sheaths; 45 c.c. reached the level of all the lumbar nerves and permeated the sheaths of the third and fourth, for a distance of 5 centimetres; 60 c.c. stained all the nerves up to the sixth dorsal; 90 c.c. colored all the dorsal nerves; 120 c.c. injected in four bodies stained the sheaths of the second and third cervicals. We have not confirmed these experiments, but have attempted to make a practical use of the idea by injecting various amounts in the clinical cases which gave varying results.

ACTION, ONSET AND DURATION

The action that takes place is a physico-chemical one, the nerves take up the solution like a dye; they have, however, a low permeability, due to their dural covering, which makes the action slower
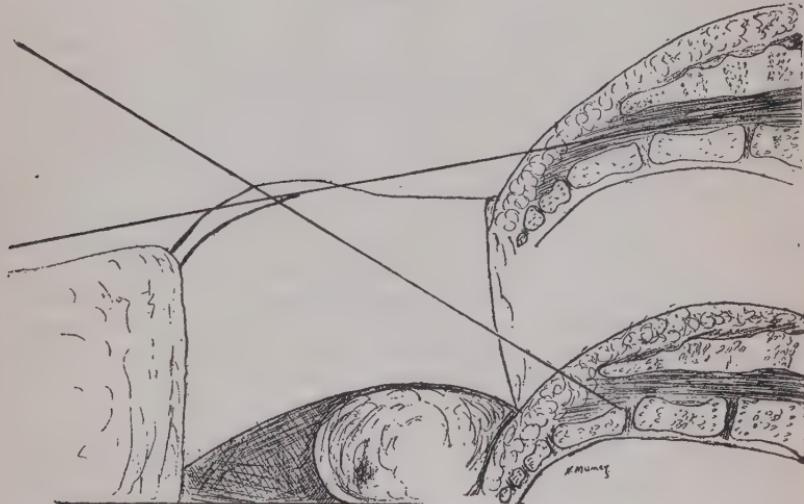
than when the solution is injected into the arachnoid space. It may require from ten to forty minutes for complete anæsthesia, it may begin in the anterior urethra in ten minutes, at the internal sphincter, bladder and prostate in twenty minutes.

The duration is about two hours, it may require forty-eight hours for complete recovery.

REACTIONS

There is occasionally some reaction when fluids are introduced into the sacral canal. This is evidenced by nausea, vomiting, dizzi-

Fig. 14.

Point showing the different angles in which insertion is made, with cross-sections of the sacrum.

ness and a rapid pulse; these symptoms are transitory and quickly pass away without treatment.

PSYCHIC CONTROL

In many instances they are of a psychic nature, therefore it is better to explain to the patient to some extent the method to be employed and make the injection before taking him to the operating room. Anæsthesia is determined by pinching the anus with a hemostat or pricking with a needle without asking any questions; if complete, there will be no pain. An assistant can help by talking to the patient, which will divert his attention during the operation.

CASE REPORTS

At Doctor Haines' clinic at the St. Agnes Hospital, this form of anæsthesia is being used in various urological conditions. As previously stated, a few failures were encountered in the beginning, which we believe were due to a faulty technic either from failure to enter the canal, or from an insufficient amount of novocaine. A total of sixteen cases are made up as follows: Seven cystoscopies, two hydroceles, one scrotal hernia, two orchidectomies, one prostatic abscess, two circumcisions and one tumor of the testicle. The following cases are mentioned in detail, to illustrate results under different conditions.

(1) The first case is that of an Italian laborer, aged 72, carcinoma of the prostate, involving the neck of the bladder. Several attempts were made to catheterize him, but a soft rubber catheter could not be passed on account of severe pain; he was not in condition for a general anæsthetic due to cardiorenal complication. Caudal anæsthesia was given for cystoscopic diagnosis. Sixty c.c. of a 1 per cent. novocaine solution were injected and within thirty minutes he had anæsthesia around the perineum and genitalia. Soft rubber catheter passed and a large amount of residual urine removed, after which the bladder walls collapsed due to a thorough relaxation of the anæsthesia as evidenced by passing the cystoscope which remained in his bladder for nearly three hours, during which time students and assistants were making observations. The patient was comfortable during this entire time, and slept at short intervals, prior to this he was constantly complaining and disturbed patients in the ward until he was moved to a private room.

(2) The second case is that of a patient, aged 23, with a urethral fistula, which extended about one and a half inches from the meatus; 60 c.c. of a 1 per cent. novocaine solution injected, which caused anæsthesia in twenty minutes. Extensive plastic operation was done without any pain and three hours later he was still comfortable.

(3) The third case was that of a patient, aged 20, right scrotal hernia; 60 c.c. of a 1 per cent. solution of novocaine injected and in twenty-five minutes the operation was started and completed without any pain or discomfort to the patient. In this instance a high level of anæsthesia was obtained, due to the fact that the two nerves encountered in hernia operations, the ilio-inguinal and ilio-hypogastric, are given off the twelfth dorsal and first lumbar.

(4) The fourth case is that of a patient aged 32, sarcoma of the testicle. Thirty c.c. of a 2 per cent. novocaine solution injected in the sacral canal; anæsthesia was obtained in forty minutes. Operation was started, incision through skin and the tunica vaginalis made without, testicle delivered; as soon as traction was made on the cord and deeper structures, the patient complained of severe pain, ether had to be given. This partial failure illustrates that the amount of anæsthetic solution gives varying results. We believe that if 60 c.c. had been injected as in the hernia, we would have obtained anæsthesia to complete the operation.

(5) The fifth patient was that of a boy of fifteen with a right hydrocele, 60 c.c. of a 1 per cent. novocaine solution injected, anæsthesia began in twenty minutes; he had nausea and vomiting which rapidly passed away without any untoward effects: The operation was completed without pain, although he had some discomfort during the suturing of the skin.

(6) The sixth case was that of a patient aged 26, with hydrocele, 60 c.c. of a 1 per cent. solution of novocaine injected, in the operating room in the presence of several physicians and nurses, the patient was allowed to observe his surroundings. He immediately became excited and asked for ether. The operation was started, he complained of a great deal of pain, a piece of gauze was placed over his face and a few drops of ether applied; after this his complaints were fewer. He said afterwards that he wanted the ether not because he suffered, but because he was afraid. This partial failure we attributed to the psychic element.

(7) The seventh case was that of a patient aged 26, suspected renal tuberculosis. Fifty c.c. of a 2 per cent. solution of novocaine injected, in fifteen minutes he complained of heaviness of the lower extremities and not being able to see clearly. He was allowed to sit up for a few minutes, after which he walked a distance of one hundred feet to the examining room. His gait was somewhat spastic and unsteady; one hour and twenty minutes later a cystoscopy was done with 300 c.c. of sterile water in the bladder; for the purpose of determining indigo-carmine excretion of the kidneys, he was observed for another hour and allowed to walk out of the clinic unassisted. During all this time there was no discomfort whatever.

Five of the total number of cases (16) are reported as failures, on account of the anæsthesia being but partial. The injections were made by three different assistants in the clinic, it being their first attempt. In two of the failures, 15 c.c. of a 1 per cent. novocaine solution were injected, the others we attribute to the fluid not entering the canal.

SUMMARY

From our observations of this method, during the past few months, we believe it to be a safe procedure, without contra-indicacations and can be carried out without hospitalization. The extent of anæsthesia depends on the amount of solution injected and not the strength or percentage of anæsthetic, this we hope to be conclusive from further experiments and observations we are carrying out at the present time. The duration of anæsthesia is long, which makes it an especially desirable method for time-consuming examinations or operations, around the bladder and perineum.

Failure by this method does not contra-indicate the use of other anæsthetics. Finally we believe that if the method, which we have

suggested, of locating the sacral hiatus is employed, in conjunction with methods described by other writers, it gives a double assurance of entering the sacral canal and putting the anæsthetic where it will come in contact with the nerves, thus minimizing the possibilities of failure.

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THE DIAGNOSIS OF RIGHT-SIDED
ABDOMINAL CONDITIONS *

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In considering the diagnostic problem presented by disease of the gastro-intestinal tract it is essential that we begin our discussion with the consideration of the development of the gut tube. In an evolutionary sense the gastro-intestinal tube is the oldest of all the organs and its many modifications in morphology and function as they exist in the human to-day are of comparatively later derivation, and the most recent of all is the attachment of the central nervous system to the gastro-intestinal tube. The alimentary tract possesses an independent automaticity of movement very similar to that exercised by heart-muscle. This automaticity and rhythmicity of movement is controlled by so-called nodal centres, four of which have been demonstrated by Keith, and four more are presumptively present. These nodal centres are located at the pharynx, cardio-œsophageal junction, pyloric junction, duodenojejunal flexure, ileocæcal valve, the midpoint of the transverse colon, the rectosigmoid junction, and at the anus. From these nodal centres independent self-initiated intestinal rhythms are maintained. At a much later point in the biological development of the human being there was an association made between the cerebral spinal nerves on the one hand and the sympathetic nervous system on the other. We may roughly speak, then, of two reflexes, a vasomotor reflex and a vasosensory, the former implying an agitated centre in the spinal cord with a reflex muscular spasm and the latter an irritability in the spinal cord with reflex distribution of sensibility to the skin and subcutaneous tissue.

By reason of the fact that the gut tube originally occupied a midline position and later deviated from the central position without any corresponding elaboration of distribution of the spinal cord, the

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spinal centres that control or are interested in intestinal movement have remained central and confined to the midline. As a result the pain of irritation of increased functional activity of the gastro-intestinal tract is ordinarily allocated to an anterior midline position. Pain as the result of increased functional activity of the œsophagus will ordinarily be located immediately beneath the xiphoid cartilage; that of the stomach and pylorus to a point midway between the xiphoid cartilage and the navel; that of the small intestine above and below the navel, while that of the large intestine from about two inches below the navel to the symphysis.

In the interpretation of abdominal pain it is most important to distinguish pain as the result of overactivity of the gut tube and pain as the result of organic change. In the former the pain is neuromuscular, referred to a midline position, of acute sudden onset. The latter is due to gross organic changes in the tissue integrity of the part, is associated with inflammation and exudation, is a vascular phenomenon, local in its position and requires a definite interval of time for its production. We can then clearly distinguish an affection that manifests itself by aberrations in normal function and one that manifests itself by actual organic change.

The gall-bladder has been under a particularly large amount of investigation in the last few years. It is interesting to note some of the anatomical peculiarities of the gall-bladder. Under normal conditions the gall-bladder is only capable of holding 30 to 60 c.c. of bile, yet the daily secretion and excretion of bile very nearly equals that of the urine; like all viscera that contain fluid its outlet—the cystic duct—is situated higher than the fundus or base. The wall of the gall-bladder contains contractile elements in the form of non-striated muscle fibres. There is a very rich distribution of lymphatics to the gall-bladder and there is no anatomical partition between those that arise from the gall-bladder and those that arise within the liver. The cystic duct forms an acute angle with the common duct and the common duct is peculiarly unfortunate in its terminal facilities, being associated with the common pancreatic duct and the duct of Wirsung, the two emptying into the duodenum at the ampulla of Vater. This termination of the common duct and the duct of Wirsung is con-trolled by sphincter muscle—the muscle of Oddi—and it is supposed

that between the gall-bladder and the ampulla of Vater there is a contrary antagonistic innervation so that contraction of the gall-bladder induces relaxation of the sphincter of Oddi. It is rather an anomalous condition that bile which is secreted continuously is delivered into the duodenum intermittently (unless the individual has had a cholecystectomy where there is a uniform dilatation of the common duct and the biliary delivery into the duodenum is continuous). It was recognized early that there was a very close relationship between disease of the gall-bladder and disease of the pancreas. Statistics vary with the personal classification of the operator, but it is considered that about 25 per cent. of all cases of cholangitis with calculi are associated with pancreatitis and that in all pure cases of pancreatitis there was an associated disease of the gall-bladder in at least 85 per cent. of the cases. Furthermore, we believe that the liver very frequently shows changes incident to chronic disease of the gall-bladder, and Graham was able to demonstrate that in every operative case of cholecystitis wherein a removal of a portion of the liver for histological examination was carried out there was the indubitable presence of hepatitis involving either the portal veins or the biliary radicles. For a long time it was considered that gall-stones were the only pathological indication for laparotomy in disease of the external biliary apparatus. We know that this is incorrect, for at least 20 per cent. of the cases in which cholecystectomy is highly desirable are those without calculi but which show extensive changes in the mucosa, the submucous layers, the muscular layers and not infrequently in the serosa. It is doubtful if the gall-bladder that has a mural infection is ever cured by drainage and that it represents a case primarily for cholecystectomy. The element that produces symptoms in disease of the gall-bladder tract is the element of infection and not the accidental association of calculi.

We may pause for a moment and consider how the gall-bladder is infected. The easiest supposition is that it is infected by an ascending infection from the duodenum along the course of the common duct. If this method of infection occurs it must be rather infrequent and theoretically is untenable as it is against the experimental evidence of the inability to infect a viscus against its natural current without the additional element of injury. Furthermore, the duodenum is the

least infective zone of the entire gastro-intestinal tract. Infection by way of the portal system, advanced and championed by Lustgarten, presupposes the permeability of the liver to living bacteria and assumes that the gall-bladder is infected by a bile contaminated by living bacteria. The experimental work of Adami proved that living bacteria could be cultivated from the bile and portal blood. Heyd and McNeal have drawn attention to the frequency of interstitial hepatitis in chronic abdominal infection. Yet, there still remains the question of infecting the gall-bladder with contaminated bile. It is almost impossible to infect the gall-bladder by the introduction of bacteria within its cavity unless the element of trauma and stasis be also present. Infection of the gall-bladder by means of infected bile without coincident infection of the ducts must be very rare indeed. Increasing study seems to suggest that the gall-bladder is always infected first and later the ducts. If this be true it renders the possibility of portal-bile infection of the gall-bladder still more dubious.

Rosenow, in a measure, succeeded in showing that some of the cases of gall-bladder disease were due to embolic processes and that a special selective affinity existed between certain bacteria and the gall-bladder. That this occurs seems most reasonable. That it is a frequent cause in the infection of the gall-bladder is not seriously contended.

The fourth method of infection of the liver or gall-bladder is by means of the lymphatic system. The fact that there is no distinction between intra- and extrahepatic lymphatics and that the liver is a buffer placed between the portal and systemic systems and prone to be affected in acute conditions of the intestinal tract is evidenced by the clinical example of thrombosis of the superior mesenteric vein with the production of septic pyelophlebitis and multiple abscesses in the liver.

A partially or completely obliterated appendix is accepted by practically every pathologist as the incontestable proof of chronic inflammatory disease. The normal post-mortem rate of diseased appendices is approximately 17 per cent. and it is no accidental finding to observe that in disease of the gall-bladder a partially or completely obliterated appendix is found in 55 per cent. of the cases and in gastroduodenal ulceration in 60 per cent. of the cases. These

facts would suggest the possibility of a septic leakage by way of the portal system with infection of the periportal veins and then a hepatic lymphangitis with a secondary infection of the gall-bladder representing in effect a sequential infection of the gall-bladder through the lymphatic system.

Of all the methods to arrive at a diagnosis in disease of the abdomen it appears to me that that method most successful is in the interpretation of a carefully taken history. Of 1000 cases of tabes dorsalis observed in a prominent clinic 10 per cent. had been operated upon for supposed intra-abdominal lesions and it is interesting to note that of this 10 per cent. operated upon for a supposed intra-abdominal lesion the three conditions designated as the cause for operation were equally divided between gastric ulcer, gall-stones and appendicitis.

The clinical history is the story of the disease in chronological sequence and practically every disease of the gastro-intestinal tract manifests two stages in its life history, the stage of functional disturbance and the stage of organic change. When we have an infection in the gall-bladder, usually expressed in terms of gall-stones, we have a thickening of the wall of the gall-bladder, a replacement of muscular tissue by fibrous tissue and ordinarily a contraction and fibrosis of the gall-bladder. Certainly, the gall-bladder is unable to distend to any great extent without conscious sensibility upon the part of the patient. We may, therefore, define the early symptoms of gall-bladder disease as the symptoms of gastric irritability by reason of the fact that when we have an irritation to the gut tube the point proximal to the irritation participates in an aberration and exaggeration of its normal function. The functions of the stomach are roughly those of secretion and motion, the latter being by far the most essential and most necessary. The clinical proof of this latter statement is to be seen in cases of achylia gastrica where there is an absence of the chemical or secretory elements and clinically there is very little gastric disturbance so long as the motor or emptying function of the stomach remains competent.

The first phase, or as it has been called, the inaugural symptoms of gall-bladder disease, are those of a gaseous indigestion. The patient complains particularly of " gas in the stomach " following an ordinary meal, but more particularly following a large meal. The

gas usually bears a very distinct relationship to the character and quality of the food, being usually elicited after fried food of any type, after carbohydrates, cheese, apples and after unusual and lightly considered articles in the dietary. There is usually a sense of fulness or oppression or a stitch in the right side beneath the costal margin suggesting a slight pleurisy. There is tenderness beneath the costal margin and rarely a sense of goose skin or chilliness may be experienced. The usual history is of taking bicarbonate of soda to "break the gas," which upon being eructated brings relief. Occasionally the patient induces vomiting, with almost complete cessation of symptoms following the emptying of the stomach. Most of these patients after a variable period of time have a change in the character of their symptomatology. There is a sudden acute attack of agonizing pain, that has a distinct predilection for nocturnal occurrence and occurs usually before or at midnight. This pain is colicky in character, of agonizing intensity, comes on like a bolt of lightning, is associated with restlessness and movement, and is usually so severe as to require the administration of an anodyne, frequently morphine hypodermatically.

In these two phases that have been discussed, jaundice has not been a symptom and jaundice is not a symptom in disease of the gall-bladder or biliary system until infection or calculi produce an obstruction to the lumen of the common duct. It may be accepted as a general proposition that all jaundice is obstructive, even the type of jaundice that occurs with hæmolytic changes in the blood is probably due to obstruction in the minute bile radicles of the liver. Jaundice means a diminution in the lumen of the bile-ducts or bile radicles. If we eliminate catarrhal jaundice, a condition without any clear pathologic basis, and also Leannec's cirrhosis, the question of jaundice becomes a differentiation between that due to infection—calculous cholangitis—and malignancy. In the genesis of a tumor the element of time is essential. A neoplasm grows by minute changes and the production of a tumor of sufficient size to bring about compression of the common bile-duct requires an interval of time that is not necessary for the jaundice due to a calculus or infective changes in the lumen of the duct. The jaundice that is due to calculous disease of the common duct is a jaundice that came on suddenly, is associated with

systemic reaction in the form of chill, fever and sweat and occurs in a patient who had a preëxisting disease of the gall-bladder or cystic duct. The jaundice that occurs in malignancy of the pancreas is a jaundice that comes on slowly. In neoplastic jaundice a friend informs the patient that he is " yellow " and from that moment, without hesitation or delay, slowly, persistently, continuously, there is an increase in the intensity of the icterus, from yellow to deep yellow, to orange, to olivary green and finally to icterus melas. This is the jaundice that in its early stages is without any other association except loss of weight. The jaundice that occurs in neoplasm is not one associated with chills, fever or sweat, is not one associated with pain and, therefore, its insidious beginning, its progressive course without systemic reaction differentiates this type of jaundice from that of calculous disease. Loss of weight in any chronic jaundice is a symptom of very little importance, for every individual chronically jaundiced loses weight through disturbance in metabolism irrespective of the pathologic causation of that jaundice.

Many years ago Courvoisier enunciated a law which is as correct to-day as when first enunciated and that is, a distended gall-bladder, or a definitely palpable gall-bladder, in the presence of a chronic jaundice is significant of neoplastic compression of the common duct, whereas a non-distended, non-palpable gall-bladder in the presence of a chronic jaundice is significant of disease of the common duct. The reason for this is very simple. In calculous disease of the common duct there has been a previous cholecystitis and the residual infection in that gall-bladder with fibrosis prevents its distention from common duct obstruction.

The mortality of acute appendicitis, taking all of the hospitals collectively, is probably about 10 per cent., a mortality that connotes little credit to the diagnostic skill of the community.

In no other intra-abdominal condition do the symptoms parallel the pathologic processes so accurately, and probably in no other organ is the pathologic sequence determined so precisely by the anatomical formation of the viscus. The appendix is a blind tube and in the adult has its narrowest aperture at its junction with the cæcum. It has a terminal blood-supply. It is particularly richly endowed with lymph tissue, and stands as a vestigial organ at the great biochemic

partition represented by the ileocæcal valve. At this juncture there is present the greatest bacterial flora of the entire intestine; the greatest degree of fluidity; the change from alkalinity to acidity; the great residual reservoir of lymph tissue.

In children under twelve years of age, the appendix lacks the submucous layer. This is the portion of the gut tube that is very strong and from which catgut is made and acute appendicitis in young children shows two characteristics that are essentially absent from acute appendicitis in adults, namely, the readiness with which the appendix of a child empties itself by intracæcal drainage, and secondly, the ease with which the appendix perforates.

Inflammatory change in the appendix of an acute nature ordinarily begins in the mucous membrane. There is a lymphocytic and leucocytic infiltration. There is obstruction to the lumen of the appendix, either at the valve of Gerlach, its junction with the cæcum or by angulation at some point along its course. The pathological process is then essentially an empyema and we have the products of an acute infection retained under pressure. What are the symptoms that parallel or correspond to this pathological state? We have, first, the development of pain and this pain is colicky in type, located in the general area of the umbilicus, of maximum intensity, with periods of intermittency and freedom from pain. This pain is due to hyperactivity of the small intestine and is essentially a small intestinal cramp due to the fact that below the ileocæcal valve there is an infective irritation and the small intestine is participating in an exaggeration of its normal function. The pain is followed by or is associated with nausea or vomiting or both. There is no right-sided pain or tenderness. Such tenderness as there may be is in the nature of general abdominal tenderness and sensibility. These three symptoms—pain, nausea and vomiting, general abdominal sensibility—are followed by temperature and leucocytosis. This is the condition in the first eighteen to twenty-four hours and this is the condition that should be diagnosed from the symptomatology as acute appendicitis.

At the end of this more or less arbitrary time limit one of three things happens to that appendix. There is drainage of the infectious by-products back into the cæcum, or there occurs a perforation or gangrene. In the event of the latter two taking place there develops the onset of a peri-appendicitis with the development of a localized

peritonitis and there ensues a change in the entire sequence of the symptomatology. Pain is present but it is constant, not colicky; it is confined to the right lower quadrant. Nausea and vomiting are absent, temperature is ordinarily present except for the few hours succeeding the perforation, and leucocytosis and polynucleosis are ascendingly present. This is the stage that acute appendicitis enters a hospital with local peritonitis.

Referring now to so-called chronic appendicitis we have an entirely different problem and a much more difficult one. We usually speak of pain in the right lower quadrant as the pain of chronic appendicitis. We had occasion some time ago to study the end-results after the removal of the appendix for so-called chronic inflammation and we were quite surprised to find that when the patient complained of gastric symptoms and where the distress was represented by types of indigestion occurring in patients without gall-bladder disease or ulcer the removal of the appendix uniformly produced a cure. The essential feature in the gastric disturbance of chronic appendicitis is purely pylorospasm induced from irritation in the region of the appendix. On the other hand, in those cases that complained of right-sided pain and where the appendix only was removed with no other operative manipulation being carried out on the cæcum, tube or ovary, there was almost uniformly a recurrence of the pain subsequent to the operation. The diagnosis of chronic appendicitis, in our opinion, has been a diagnosis of exclusion—of excluding gall-bladder disease and excluding ulcer of the gastroduodenal segment. This corresponds very closely to the aphorism that the most frequent site for the cause of symptoms which simulate ulcer is in the right lower quadrant.

I would like to refer briefly to gastric and duodenal ulceration. Ulcer means a definite loss of substance and connotes that there has been a definite interval of time required for the production of the ulcer. It follows, therefore, that once an ulcer is established and is producing symptoms, the symptoms are chronic and repeat themselves daily with almost unvarying precision. While it is true that there are certain definite and special characteristics to certain types of ulcer which enable us to localize roughly the location of an ulcer, yet the three types of ulcer—(a) those confined to the area of the stomach

proximal to the pylorus, (*b*) those at the pyloric ring and (*c*) those in the duodenum—are essentially the same, insofar as the main grouping of their symptoms. In the clinical diagnosis of ulcer of the gastroduodenal segment three symptoms stand out, the first is that the patient complains of pain, the second is that the onset of the pain bears a certain definite relationship to the time of ingestion of food and the third feature is that these symptoms under the same conditions of food intake are repeated in almost unvarying precision day after day. If on Monday a given breakfast at eight o'clock produces pain at eleven o'clock, it will reproduce the same pain on Tuesday at eleven o'clock after the same breakfast at eight o'clock. These three features are repeatedly present day after day and occur in 88 per cent. of all ulcers. The loss of regularity of symptomatology is a strong factor in the presumptious diagnosis of malignancy, for irregularity is habitual to malignancy, being present in about 99 per cent. of malignancies of the stomach.

Depending upon the location of the ulcer, you have variations in the physical condition of the patient. An ulcer high up on the stomach induces vomiting of partly digested food and the patient shows loss of weight and color, primarily from starvation. An ulcer at the pylorus is early associated with pyloric spasm and then later with an invasive process and occlusion of the pylorus. For some time the muscular force of the stomach is sufficient to project food through the restricted pylorus but there comes a time when muscular atony sets in and there results a dilatation of the stomach proximal to the pylorus. We have then a water-trap stomach with putrid, fermenting food material and the patient early shows starvation plus cachexia, starvation from inability to properly pass food through the pylorus and cachexia from the absorption of putrescent food remnants. Duodenal ulcer does not interfere with the pyloric passage and this patient maintains his nourishment, with weight, color and no evidence of either cachexia or starvation. The interval between the partaking of food and the development of pain is of value only in roughly localizing an ulcer. The nocturnal recurrence of pain is also of value in suggesting duodenal as against gastric ulcer. The importance of localizing an ulcer rests in the fact that ulcer distal to the pylorus shows little, if any, likelihood of malignant change while those proximal to the pylorus have the potentialities for developing cancer.

I know of no way to diagnose cancer of the stomach positively and early. Unfortunately, malignancy is without a pathognomonic sign, and the early diagnosis of cancer of the stomach in the absence of X-ray diagnosis must to a large extent be founded upon suspicion. Cancer of the stomach usually manifests itself in one of three ways: In the first group (60 per cent.) of patients coming to operation for cancer, there is a definite history of preceding gastric distress that has all the characteristics and symptomatology of ulcer. It has been characterized by a pain coming on after ingestion of food and which repeated itself from day to day. This history has extended over a period of at least eight years, with intervals of complete cessation of symptoms for varying periods from three to five months. After a time there is a period of gastric distress which is not particularly different from those that have preceded it but with which there is physical deterioration out of all proportion to a simple ulcer of the stomach.

The second group (30 per cent.) is characterized at the onset by gastric distress that closely parallels the symptomatology of acute gastric ulcer but at the end of two or three months the patient has not responded to medical treatment. This patient does not respond to measures that in other cases had been successful and he has failed out of all proportion to the physical deterioration that one sees in a typical ulcer. At laparotomy there is revealed a carcinoma of the stomach and the patient's duration of life from the onset of symptoms until his death is approximately eighteen months.

The third group, of about 10 per cent., occurs in patients who have never had a single sign of gastric distress. They have, on the contrary, been patients to whom we give the appellation of " athletic stomach." At about forty-five years of age they begin to have a vague, indefinite, atypical, irregular type of indigestion, associated with a dislike for food and a disinclination to eat. Some days they feel reasonably well and others considerably distressed, with ill-defined sensibility in the epigastrium. They may have a gastric hemorrhage as their first symptom, and at laparotomy they reveal a diffuse, infiltrated carcinoma and the average duration of life is about eleven months.

SYPHILITIC AORTITIS, WITH SPECIAL REFERENCE TO TREATMENT

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WITHOUT entering into a detailed study of the history of aortitis, I would simply recall that Vieussens was the first to describe aortic insufficiency of aortic origin, observed by him in 1715, in a patient whose autopsy showed " thickened, distended and cartilaginous walls (of the aorta), the semilunar valves being greatly distended and their edges ragged." He also described the majority of symptoms of aortic insufficiency.

To Morgagni and Boerhaave we owe the first description of the morbid anatomy of aortic lesions. The former frequently refers to a symptom which is merely exertion dyspnœa, " the patient experiencing great difficulty in breathing when walking on the level, which is increased when going up an incline."

A century later, Hodgson described aortic insufficiency following simple dilatation of the vessel and its orifice. After him the great clinicians of the nineteenth century developed the subject of aortitis and Fournier drew particular attention to the part played by syphilis and outlined the specific treatment of the affection. Since the use of the Wassermann reaction and the discovery of the treponema in the vascular coats the subject of aortitis has been greatly enlightened, so that at present it is an established fact that syphilis is the most constant etiological factor of the disease. At the Congress of Medicine, held in Brussels in May, 1920, Etienne collected a total of 330 cases of simple thoracic aortitis and found syphilis in the antecedents of 268 cases, otherwise a proportion of 82 per cent.

Cases have been recorded in which the Wassermann was inconstant although the previous treatment could not explain the negative blood reaction. A negative Wassermann is not a proof that an aortic lesion is not luetic and this is proved by the amelioration obtained by a test treatment. On the other hand, a positive Wassermann in cases of paludism is suspicious, although malaria has been supposed to be

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an etiological factor of chronic aortitis. Unquestionably it may have a pathogenic action, just like rheumatism, gout, variola or typhoid fever, since these morbid processes are known to give rise to acute aortitis, but such instances are few, so that *in every case of aortitis, syphilis should be suspected.*

It is well to recall that the abuse of tobacco favors the action of syphilis on the vascular system, likewise alcohol and certain foodstuffs.

Now, just as one should think of syphilis in a case of aortitis, so one should think of aortitis in every syphilitic subject. The importance of syphilis in aortic processes is so real that if aortitis is searched for in old syphilitics it will frequently be found to exist. The coincidence of aortitis and tabes has been known for years and many statistics have been published on this subject. According to Spillmann one-eighth of the patients with locomotor ataxia present cardio-aortic lesions.

Besides the coincidence of aortitis with Argyll-Robertson's sign, Loeper and Mongeot have called attention to the co-existence of aortitis and absence of the oculocardiac reflex, which is a sign of syphilitic localization in the bulb. This sign occurs earlier in the process than absence of the pupil reflex to light. In tabes, aortitis is often latent, but it may also evolve without giving rise to very marked subjective disturbances on account of the change arising in the deep sensory system in locomotor ataxia.

In general paralytics aortitis is common. In 1904, Guilly published statistics of 233 cases of paresis with fifty-one instances of aortitis. Lastly, aortitis has been found in cases of hereditary syphilis presenting the same lesions as in the acquired form of the infection. Subacute aortitis in young subjects and the fœtus is usually fatal, while chronic aortitis represents a lesion of adult life in the tertiary phase of the infection; hence, it is met with in subjects advanced in years.

The point of election of syphilitic aortitis is the suprasigmoid area, hence the frequent involvement of the coronary arteries in the inflammatory process. The aortitis becomes combined with coronaritis which in turn causes cardiac insufficiency, setting up angina pectoris from left-sided ventricular insufficiency or acute pulmonary œdema from asystolia of the left heart.

Very frequently aortitis extends to the aortic sigmoids, causing insufficiency or aortic narrowing, or a combination of the two lesions, and by extension to the mitral valve a mitro-aortic lesion ensues. In 1898, Letulle showed that lesions were disseminated along the vascular trunk in the form of patches and that the three arterial coats were involved. A panarteritis is characteristic.

In recent cases the aorta appears normal, but nevertheless its characteristic histologic changes exist. In old cases the typical aspect of syphilitic aortitis is hidden by a superadded diffuse atherosclerosis.

Macroscopically the aorta offers an embossed aspect. The increased thickness of its walls is notable. The lesion at its onset is constituted by the appearance of *gelatiniform patches,* of varying extent, single or in clusters, forming an appreciable relief on the lumen of the vessel. They early undergo fatty degeneration, and soon are covered with fibrinous vegetations. The gelatiniform patches located at the origin of the arterial trunks—coronaries, subclavian and left carotid—may involve the entire circumference of the arterial opening, hence causing notable narrowing of its lumen.

Microscopically, the external coat contains foci of inflammation which are prone to accumulate over the vasa vasorum. Fukushi has pointed out that these foci, composed of lymphocytes and plasmazellen, may involve the entire thickness of the middle coat and adventitia and that the vasa vasorum are the seat of an obliterating endarteritis.

The middle coat—which is almost entirely elastic—becomes dislocated by lines of young cells which insinuate themselves parallelly to the surface and become condensed into foci between the elastic fibres which they spread apart. Letulle says that " these broken and separated fibres little by little give way to a tissue composed of succulent granulations but with a manifestly insufficient vitality and vascularity," which is the characteristic of syphilis.

The intima is always more or less involved, being thickened and infiltrated by cell elements. The change in the middle coat, resulting from dissociation of its elastic fibres, causes a lessened resistance of the vessel walls, which are finally overcome. By this mechanism

an aortic dilatation ensues or, when the resistance of the aortic wall gives way over a circumscribed area, an aneurism develops.

The treponema has been found in the lesions of the aorta by Reuter, Schmol, Wright and Richardson and Fukushi. Sézary supposes that the organism penetrates the vascular tunics from within outwardly, while Rumpf maintains that it attacks the vessel by way of the vasa vasorum.

But when does the treponema become fixed in the aorta? In the secondary phase of the infection it invades the organism and it is during this phase of generalization that it may become settled in the walls of the aorta. All this may occur without any symptomatic manifestation, resulting in a mild, latent lesion in which the treponema waits to regain its virulence from a too lengthy suspension of specific treatment or from some other cause. Or else, but less frequently, the organism becomes installed with more evidence, producing a more or less intense inflammatory lesion during the secondary phase and presenting the same clinical picture as the subacute aortitis of the tertiary period. In 1899, Huchard noted that syphilitic aortitis could arise in less than two years after the primary lesion, but that such an event was unusual.

A more careful examination of syphilitics at the onset of their infection should allow one to detect the initial phase of aortitis. Fournier has described cases of syphilitic females who suffered from attacks of palpitation shortly after the onset of the infection, with tachycardia occurring during or even before the advent of the roseola, as well as cardiac arrhythmia perceived by the finger and especially with the sphygmograph, all these symptoms improving with antiluetic treatment.

Du Castel has noted that the orthostatic dyspnœa and effort tachycardia are much more frequent in syphilitics than in other subjects, while Leredde has recently referred to a "morning arrhythmia," in the sense that the rapidity of the pulse varies from one morning to another. Milian has noted the frequency of an arrhythmic tachycardia occurring during the secondary phase of syphilis—no murmurs but high blood-pressure and arrhythmia with from 120 to 140 pulsations.

All the above morbid conditions pertain more to syphilis of the myocardium than to aortic lues, but perhaps the myocardium would

not be involved unless there is at this same time a latent lesion of the aorta. During secondary syphilis, an abnormally intense pulsatile rate of the heart and arteries is met with which may be attributed to a certain degree of aortitis. Therefore, in every case of secondary syphilis the slightest functional symptoms and physical signs of aortitis should be sought for in order to deal with it at its onset and hence avoid the ensuing complications.

The symptoms of simple aortitis are in part governed by its special topography, which is limited to the sigmoid area. They are rarely all present, the subjective signs being the most constant, while the objective signs may be entirely absent. This is most apt to be the case at the onset of the aortitis, consequently the diagnosis of aortitis must never be discarded until a radiological examination has been made. The functional symptoms may be so mild that an aortitis is discovered in a subject who consults the physician for something altogether different.

Subjective Signs.—The *dyspnœa* offers very variable characters. At the onset it is usually an effort dyspnœa arising when the patient walks up an incline or against a strong wind. At times it is violent and paroxysmal, increasing with the slightest effort on the patient's part. At others it occurs when the patient is quiet, preferably at night, thus simulating an attack of asthma. The subject awakes suddenly soon after falling off to sleep in prey of an intense dyspnœa. The attack is short, progressively subsiding, the cough being dry and paroxysmal. In other cases—during coitus frequently—the attack lasts much longer and gives rise to a frothy pink expectoration and auscultation detects crackling râles due to acute pulmonary œdema. The reflex origin of these attacks of dyspnœa has been demonstrated by F. Franck.

The *pain* assumes several types, but its essential character is that of great distress. It is often an early symptom.

(*a*) Precardiac pain, similar to that of angina pectoris, with extension to the neck, shoulder, arm and ulnar aspect of the forearm and hand, usually the left. An immediate diagnosis can be made from this classic clinical picture.

(*b*) Retrosternal pain, more or less intense, and distressing, with an indescribable feeling of oppression, with transversal irradiations,

either occurring in attacks or permanent with superadded pain-
ful palpitation.

(c) Pain with epigastric irradiations, recalling gastric crises of
locomotor ataxia. Occasionally there is reflex dysphagia and vomiting.

Independently of these symptoms, the patient may experience
vertigo or tinnitus aurium, especially when changing from the recum-
bent position to sitting or standing, caused by disturbances of the
general circulation, the aorta being the starting-point of the reflex.

Objective Signs.—The objective signs which permit one to
attribute these disturbances to their true cause are derived from
percussion, palpation, auscultation and radioscopy. Inspection usu-
ally reveals nothing.

Palpation and percussion reveal three signs either existing
together or separately. These are: An elevation of the aortic dome
behind the sternal notch, where its beats can be distinctly felt; a
broadening of cardiac dulness extending beyond the right sternal
border at the level of the first and second intercostal spaces; elevation
of the subclavian above the clavicle.

These three signs indicate a marked dilatation of the aorta, but
their absence does not imply that aortitis does not exist. In point of
fact, an aortitis at its onset or a pathologic change at some other part
of the vessel may give rise to the subjective symptomatology outlined
above with entire absence of the three objective signs.

Auscultation gives less certain information. A systolic or diastolic
murmur may be detected, or a double murmur remaining localized
at the cardiac base in the normal area of the aortic sounds may be
heard, when there is an aortitis without dilatation. In aortitis of the
ascending portion of the aorta with dilatation, a diastolic murmur
due to functional insufficiency may be heard, although no lesions of
the sigmoid valves exist in the true sense of the word. But generally
speaking, such abnormal murmurs indicate that the pathologic process
has involved the aortic valves, and for that matter, they may exist
although the lesion has not extended beyond the area of the sigmoids.

Very frequently, especially at the onset of the aortitis, they are
reduced to a mere increase of sonority of the first sound, due to
resonance of the aortic walls deficient in elasticity, or an accentuation
of the second sound when the blood-pressure is high. This second

sound becomes metallic when the walls of the vessel are hard and rigid or calcified.

Radioscopy is the surest procedure for making a diagnosis of aortitis. It controls and explains the data obtained by palpation and percussion. It is of great import to outline the aortic lesion, because it is by repeated radiological examinations at intervals of several months that the evolution of the process can be estimated.

When clinical examination does not objectively connect the functional disturbances with their true cause, X-ray examination will reveal the aortic lesion, an important fact, because it is in cases of diffuse aortitis or at the onset of the process that treatment will be most effective.

The orthodiagram obtained by Vaquez and Bordet's method of radiologic examination gives in detail the state of the aorta. It comprises a volumetric analysis which furnishes the dimensions of the vessel, hence the extent of dilatation, and a qualitative analysis revealing the opacity of the aortic shadow, be this uniform or in patches. A decrease or absence of pulsation gives the degree of elasticity of the vessel, likewise the amount of thickening, calcareous infiltration and flexuosity.

The dimensions of the aorta are obtained by the procedure of the three dimensions, namely, the transversal diameter of the arch in frontal position of the patient; the chord of the arch; the diameter of the ascending aorta, in right oblique anterior position.

In chronic aortitis there is a more or less considerable increase in the diameters and chord. The increase of one dimension usually causes an increase of the other two. An increase of the transversal diameter indicates a moderate dilatation of the vessel. An increase of the chord indicates that besides an aneurismal sac, there is an elongation of the aortic curve with an elevation of the apex of the arch.

In cases of diffuse aortitis, the vessel is not much enlarged; in the oblique position its calibre is normal, but the presence of very dark patches due to areas of calcareous infiltration and the more or less complete absence of pulsation indicates thickening and rigidity of the walls.

Aortitis extending to the sigmoid area may result in aortic insufficiency. It frequently coincides with signs of arteriosclerosis, high

blood-pressure and nephritis. The sigmoid valves may or may not be involved in the process. When they are not involved the case is one of aortic functional insufficiency, otherwise Hodgson's disease.

When the valves are diseased there is valvular insufficiency due to extension of the suprajacent aortic lesions to the sigmoid area.

The signs of aortitis are variable. There is distressing effort dyspnœa. Pain assumes the various types of angina pectoris or painful palpitations; it may radiate to the epigastrium. Objectively, the aortic dome is raised.

The widening of the cardiac dulness, elevation of the right subclavian, and a diastolic click of the second sound confined to the aortic area are symptomatic. Its tonality is weaker in dilatation of the aorta than in simple aortitis and it becomes more quickly attenuated during the evolution of Hodgson's disease than in valvular insufficiency.

A diastolic murmur is the foremost sign of aortic insufficiency. In Hodgson's disease it is soft. Trémolières and Caussade have shown that, in recent cases, the area of the murmur is to be found to the left of the midsternal line, progressively changing to the second right intercostal space while the axis of the aorta becomes inclined on the vertical following a displacement of the heart, the result of transversal hypertrophy of the left ventricle and dilatation of the right cardiac cavities.

In valvular insufficiency the murmur is rough and sharp, with a tendency to extend in all directions. A soft, variable systolic murmur, frequently coinciding with the diastolic murmur and producing a " to-and-go " murmur, may be produced by a concomitant stenosis or a relative stenosis from dilatation of the aorta, or simply from the passage of the blood over the rugose surface of the vessel. In consequence of the insufficiency there is first hypertrophy of the left heart and afterwards dilatation of the right cardiac cavities. Therefore the cardiac dulness becomes increased and the heart's apex being lowered gives rise to Bard's " choc en dôme."

The arterial system is profoundly involved in the sclerotic process; interstitial nephritis is a serious complication from the viewpoint of treatment.

A study of the arterial blood-pressure will give important data.

The maximum pressure is high, the minimum normal or even below normal, hence it follows that the pulse is bounding as far as is permitted by the arterial sclerosis. Gallavardin has shown that the diastolic incline of the pulse is more marked in aortic insufficiency of aortic origin than in Corrigan's disease or even in aortitis without insufficiency.

Finally, radioscopy will give somewhat different results according to whether the insufficiency is of recent date or of long standing, but the characters of aortitis are always found, it being the essential causative process, to which those of insufficiency become added.

The shadow on the screen reveals dilatation of the aorta; the vessel is found to be widened in its ascending portion and sinuous; the greater the thickening of the walls the more reduced will be the pulsations. Hypertrophy of the ventricle will be observed dependent upon valvular insufficiency and the older the lesion the greater will be the shadow of the organ in a transversal direction. The left contour is elongated and projecting; the apex rounded and lowered. At length there results a shadow that Beaujard and Callods call " a transverse aortic heart " and when such is the case, the aorta is strongly inclined to the right.

Pure aortic stenosis, without aortic insufficiency, is rare. However, Etienne records six instances in which syphilis was the causal factor and in none of the patients was there any history of rheumatism. The symptomatology comprises the usual signs of aortitis and signs belonging properly to the stenosis, but as they are classic, I would only refer to the systolic murmur. This is rough and intense and extends to the aortic area and must not be confounded with the soft systolic murmur produced by the relative stenosis occurring in Hodgson's disease. Radioscopy reveals hypertrophy of both ventricles, especially the left, with uniform enlargement of the aortic shadow both in frontal and right anterior oblique positions. This shadow is particularly dark, with appreciable pulsations.

The co-existence of aortic insufficiency and stenosis is very frequent. The symptoms properly belonging to them are present in this pathologic combination which is essentially characterized by a hard, rough double systolic murmur.

Mitro-aortic disease is due to the extension of the suprasigmoid

aortitis to the sigmoid valves in the first place, then to the mitral valve. The symptomatology comprises the signs of the aortic lesion and those of the superadded mitral lesion. The mitral systolic murmur can be heard in two independent areas, extending to the axilla, and the systolic aortic murmur of the aortic stenosis.

I will not dilate upon the consequences and complications of aortitis, but I would refer to syphilitic aortitis of the left ventricular insufficiency type, described by Gallavardin in 1913, which gives rise to no aortic symptom, only to one of its cardiac consequences. The left ventricular insufficiency is, in this case, the first symptom of a cardiovascular syphilis that had been, until then, latent.

The extension of the aortic pathologic process to the coronary arteries may produce angina pectoris. The inflammation of these vessels causes myocarditis, resulting in cardiac insufficiency, thus explaining the possibility of attacks of asystolia and angina pectoris. In thirty-six cases of syphilitic aortitis observed by Gallavardin, it occurred in fifteen. Fournier mentioned angina pectoris in syphilis even in the apparent absence of cardiac or aortic lesions. Rheumatism, gout and tobacco may cause angina pectoris, but only exceptionally, and its genesis should be practically always attributed to lues.

Acute pulmonary œdema is a late complication of aortitis when the cardiac muscle has become insufficient due to myocarditis, the result of coronaritis. The aortitis is then very frequently complicated by nephritis. It is difficult to determine the etiological part played by the aortitis and nephritis, but the latter distinctly acts on the element of intoxication. This is a formidable accident many times met with during treatment of syphilis with the arsenobenzols, when cardiac insufficiency exists.

Finally, aortic aneurism, whose development depends upon the deep lesions of aortitis in limited areas, should be regarded both by its nature and genesis as a variety, rather than a complication of syphilitic aortitis.

The present medication of aortitis is the same as for syphilis, namely, mercury, arsenic and iodine. None of them possesses a superiority over the others. They must be associated in order to constitute an effective treatment, which should be energetic and prolonged. It essentially comprises a mercurio-arsenical treatment and

a complementary iodine treatment. The mercurio-arsenical method as I carry it out may, theoretically, be divided into two treatments, the first being *a prudent attack on the aortic lesion*. This comprises several series of intravenous injections of mercuric cyanide and novarsenobenzol. Each series is carried out as follows:

(1) A mercurial course of from ten to twenty intravenous injections of mercuric cyanide, of one centigram each, given daily or every other day and covering a space of three to six weeks. The cyanide occasionally causes colic and diarrhœa which may be bloody, in which case intramuscular injections of mercuric biniodide or benzoate are to be given as they are better tolerated, while the enteric phenomena are to be calmed by opiates.

(2) The arsenical course, of three to six weekly intravenous injections of novarsenobenzol in increasing doses. The arsenical course overlaps the mercurial course. The first arsenical injection is given after the third or fourth cyanide injection; it should be very mild, from 5 to 15 centigrams, in order to test the patient's susceptibility. In the dosage one should be guided by the patient's general condition, the state of the renal functions, but still more by *the extent of the aortic lesion and above all by the condition of the myocardium.*

It is important to order complete rest after each injection. If the first injection gives rise to no reactional cardiac or vascular phenomena—and very often this reaction is represented by some precardiac pain lasting for some hours—one is authorized to increase the dose of arsenic at the second injection. In advanced cases the increase should be from 5 to 10 centigrams, while in subjects with a resistant myocardium the dose at each injection may be increased 15 centigrams. *One should not try to reach the normal dosage after the first or second injection.* The progression should invariably be extremely prudent, therefore very slow. My treatment is as follows:

First week
{
4 intravenous injections of mercuric cyanide of 0.01.
1 day rest.
1 intravenous novarsenobenzol, 0.05 to 0.15.
1 day rest.
}

Second week
{
4 intravenous mercuric cyanide, 0.01.
1 day rest.
1 intravenous novarsenobenzol, 0.10 to 0.30.
1 day rest.
}

The third, fourth and fifth weeks are the same, only the novarsenobenzol is increased as follows: Third week, from 0.15 to 0.45; fourth week, 0.20 to 0.45; fifth week, 0.25 to 0.45.

In order to obtain a durable improvement the interval between the series should be as short as possible, so that the lesion will not have time to recur, because otherwise one would be in practically the same conditions as when the first series were given, while the state of the myocardium would, perhaps, be less good. An interval of from two to three weeks would seem to be the maximum time between the two series.

During the second series, which may be more energetic than the first, the first dose of novarsenobenzol may be larger than the initial dose of the first series, while the progressive increase can be more rapid, but this should always depend upon the reactional phenomena that follow each injection.

The Massive Treatment of Syphilitic Infection.—When one or several series have resulted in improvement of the aortic manifestations, the patient should no *longer be regarded as an aortic case,* but as a case of syphilis in evolution and should at this time be treated as such, that is to say, he should be capable of undergoing the classic treatment of attack of the early secondary phase, without danger of pulmonary or myocardiac reactional accidents.

The complementary iodine treatment can be carried out by 2 grams KI daily by mouth or intramuscular injections of oily preparations of iodine. The latter seem to be more active. Generally speaking, I do not resort to iodine unless the results obtained from mercurial and arsenical treatment are insufficient.

The treatment, as above outlined, must naturally vary with the different clinical conditions present. The results likewise are different according to the length of time the lesions have been present.

Without generally being an absolute contra-indication for specific treatment, cardiac insufficiency requires great prudence on the physician's part. Consequently, in carrying out treatment and in respect of results, I make a distinction between *aortitis without signs of cardiac insufficiency and aortitis with insufficiency of the myocardium.*

In the former are included aortitis in the initial phase only presenting subjective signs and aortitis with more or less long-standing subjective and objective signs.

In the second class I separate aortitis in which a slight cardiac insufficiency allows an arsenical treatment usually combined with cardiotonic medication, from aortitis in which specific treatment must be discarded, at least until cardiotonic medication shall have procured a sufficient improvement so that mercury only can be given.

(1) *Aortitis in the Initial (or Larvate) Stage.*—These are usually only cases presenting subjective symptoms, especially angina pectoris, or merely palpitations, slight effort dyspnœa or more or less fleeting attacks of distress. Examination reveals no objective signs and X-ray examination is generally negative.

An energetic treatment is essential; the patient bears it well and no difficulties are encountered. During the first series of injections the patient experiences great relief, the pain and dyspnœa cease as if by enchantment. But the treatment must not be stopped and is to be continued until complete sterilization of the lesion is obtained. This is realized after several series; however, the Wassermann remains positive for a long time, so that it must be made negative by continued interrupted treatment. It is in these cases that the best results are obtained.

(2) *Aortitis in Its Initial Stage, without Cardiac Insufficiency.* —Here one is dealing with more or less long-standing lesions, the suprasigmoid region only being involved, or with involvement of the sigmoid valves. All the objective and subjective signs are here present. The myocardium is resistant, but is nevertheless diseased, so that great care must be taken in giving arsenic. The kidneys also may be defective, and although they may appear to be normal and the blood-pressure about normal, these patients have fragile kidneys. Treatment should be as energetic as the kidneys will allow, because when the aortitis becomes complicated by nephritis, difficulties in treatment will greatly increase because renal elimination will be interfered with.

The first dose of arsenic must be small, and with care progressively increased, but the cure may be almost as energetic as in aortitis at its onset. Subjective improvement is quite as rapid and X-ray control shows an improvement of the objective signs. When the lesion has involved the valves, treatment will only be effective in the period of evolution, when the pathologic process may become arrested with

even some retrogression, but cicatrization of the lesion will not cause the valvular disturbances to disappear as they resist all treatment.

In this group of aortitides may be included aortitis with aneurism. Mixed treatment is indicated and the results are good insofar as the syphilitic process may be arrested with retrogression of the concomitant peri-aortitis and mediastinitis. The subjective signs are often very much improved but of course the aneurism remains.

(3) *Aortitis with Slight Cardiac Insufficiency.*—This group includes aortitis with excitability and slight failure of the myocardium, but mercury and arsenical treatments can be given. There is usually high blood-pressure due to sclerosis of the vascular system. The heart is dilated with intermittent extrasystoles or short attacks of extrasystoles. Renal elimination is also somewhat involved.

Before undertaking specific treatment the heart must be braced up with digitalis or sparteine in moderate doses, repeated in rather long intervals, combined with a hypotensive treatment. In the intervals of digitalis treatment the mercury and arsenic cure is carried out, but acute pulmonary œdema must be prevented, hence very small doses of novarsenobenzol—0.05 to 0.15—should first be given and very carefully increased 0.05 at each successive injection. It is better to give some mercury first in order to prepare the patient for the arsenic. Therefore 12 to 15 injections of 0.01 mecuric cyanide are given during the space of two weeks, after which the arsenic is begun. The results are often favorable, but frequently of short duration.

(4) *Aortitis with Distinct Signs of Cardiac Insufficiency.*—Here there are serious disturbances of the cardiac rhythm. The signs of aortitis are obscured by signs of insufficiency of the myocardium, while a concomitant nephritis is the rule. An energetic antisyphilitic treatment is out of the question and arsenic offers too many dangers. Above all, symptomatic cardiac medication is indicated with a severe diet, and it is only when the heart appears to sufficiently fulfil its functions that a very prudent mercury treatment can be resorted to.

If mercuric cyanide is used daily the total amount of the salt injected should not exceed 0.10 to 0.15 centigram. If the intramuscular method is used we prefer mercuric biniodide or benzoate, in the dose of 0.01 daily or every second day, a series consisting of ten to fifteen injections.

Neurology

THE SYMPTOMATOLOGY AND THE TREATMENT OF THE PARKINSON-LIKE SEQUELÆ OF EPIDEMIC ENCEPHALITIS *

A CLINICAL LECTURE TO PHYSICIANS DELIVERED AT THE UNIVERSITY HOSPITAL, BALTIMORE, MARYLAND, ON DECEMBER 6, 1923

By LEWELLYS F. BARKER, M.D.

It was in 1918 and 1919 that in the United States we first saw cases of epidemic encephalitis. At the time we had not the slightest idea of the gravity of the malady before us. We had no conception of the multitude of clinical forms of the disease that we were to see. We had no idea of how difficult the diagnosis would prove to be in many cases; and, especially, we had then no glimpse whatever of the terrible sequelæ that were in some instances to follow an attack. We thought that if the patients got over their first attack they probably would be well afterward; but, later on, we were surprised to find that some patients who had apparently recovered entirely or who had only slight signs left, a few months afterward or a year or more afterward began to develop syndromes that were very disturbing to the physical welfare or to the mentality of the patient. Indeed, we now know that the disease shows many analogies, so far as the clinical manifestations are concerned, to lues, and it is becoming customary to divide the symptoms of epidemic encephalitis into three main groups, or the course of the disease perhaps into three main stages—first, second and third—just as lues can be divided in its clinical manifestations into primary, secondary and tertiary stages.

In the first stage of epidemic encephalitis we have the grippe-like phenomena, with fever and drowsiness, and, depending upon the localization of the virus, meningeal symptoms, spinal cord symptoms, bulbar or basal ganglion symptoms, or cerebral symptoms.

The patient may apparently recover at the end of this stage, or after the first acute stage has passed, a second stage may be entered

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* Revised from stenographic notes made by Miss Mary E. Reik.

upon, in which there are residual neurological manifestations (paralysis or hyperkinesis) or various psychic disturbances are in evidence. Occasionally, there is a remission without symptoms between the first and the second stages; or there may be a remission (with apparent cure) between a second and a third stage.

In the third stage, when there is one, we see certain very remarkable clinical pictures—now often referred to as post-encephalitic syndromes, with (1) symptoms like those of paralysis agitans except that the tremor is not usually marked, (2) vasomotor disturbances, (3) marked trophic disturbances or (4) disturbances of temperament, especially when the disease occurs in children or young adults. The whole character and personality may be so altered that one may find that he has to deal with quite another individual, an individual that may find great difficulty in social adjustments, and so great that he may even come into conflict with the law.

Now, we have before us to-day a striking example of a metencephalitic parkinsonian syndrome in association with interesting nutritional and endocrine disturbances. The patient lying here on the couch is, as you will have noticed, rigid and immobile; and she moans continuously without apparent cause. She asserts that she has no pain, though she was a little apprehensive about coming into the clinic; but even when she is at rest in the ward, she moans much of the time.

The history of the patient is very interesting indeed. She suffered from what was believed to be an attack of influenza in 1919, some four years ago. She is now twenty-six years of age, so that the onset of her trouble was at the age of twenty-two. She was sick only two weeks with her " influenza," which is said to have been very severe, and she apparently recovered completely from it. At any rate, she presented neither at the time nor soon afterward any phenomena that were recognized as symptoms of encephalitis. Later on, however, on September 30, 1921, she entered this hospital (service of Professor Pincoffs) complaining of weakness, nervousness, loss of appetite and loss of weight. She stated on admission that, except for minor ailments, she had been a well person practically all her life. She had had measles, whooping cough, erysipelas and mumps in childhood. Her appendix had been removed a few years ago but

otherwise she had been well except for the attack of influenza to which I have referred. She continued to be well after recovery from this infection until a year and a half later, in the spring of 1921, when she became slightly ill, and noticed that she was growing weak and nervous; headaches occurred from time to time and she observed that she was beginning to lose weight and to lack appetite. Her friends report that at this time she seemed " to have less ambition than formerly " and that she was not so participant in the life about her as she had been. During the summer she grew gradually worse, and, finally, she applied to this hospital, on September 30, 1921, for examination and for treatment.

It was obvious, on admission, that there was some facial paresis on both sides, more marked on the left than on the right. There was also a little drooping of both eyelids and she had difficulty in turning the eyes lateralward, though the pupils were normal. Aside from these symptoms pointing to paresis in the domain of several cerebral nerves (N. III, N. VI, and N. VII) on both sides, there was no evidence of paralytic lesions. She had some nausea, and was markedly underweight (weighing only 100 pounds instead of her normal 132 pounds). She complained of insomnia and of incapacity to do household work. On closer inquiry it was ascertained that there had been a period of abnormal drowsiness earlier. The onset of these abnormalities had been insidious, but the symptoms had progressed steadily up to the time of entrance to the hospital.

Other than the points just mentioned, physical examination revealed a slight von Graefe sign, and the thyroid was slightly enlarged. The heart and lungs were normal. Examination of the abdomen was negative except for an old appendectomy scar. The deep and superficial reflexes were a little diminished but none was lost. There was no evidence of sphincter disturbance. The Babinski sign was negative on both sides, showing that there was no lesion of the pyramidal tracts. Examination of the blood revealed a slight secondary anæmia. Wassermann reaction in the blood-serum was negative and the cerebrospinal fluid was negative in all respects. The urine was also negative. Doctor Pincoffs, however, on the data available made a diagnosis of epidemic encephalitis.

The patient was kept under observation in the hospital for about

three weeks. During this period, a neighboring patient was rather noisy to which she attributed the fact that her sleep did not improve. She was sent to rest quietly in the country and was advised how to go on with general upbuilding measures in the hope that "conditions would right themselves." They did not, however, right themselves. The patient continued to be ill, and to be incapacitated for any household work.

On her re-admission she stated that ever since the autumn of 1921 (that is, over two years ago) she had been at home lying upon a couch, unable to participate in the family life. For a time she was able to get up, to walk about a little, and to go to her meals, but she showed a marked lack of initiative, a lack of spontaneity, both physical and mental. In recent months, her condition has grown steadily worse, and she has returned to the hospital for further examination and advice.

When she returned it was found that a very great change had taken place in her condition during the two years that had elapsed since the former admission. The patient now presented a very marked post-encephalitic parkinsonian syndrome. The parkinsonian phenomena will be clearly evident if you will note how she answers any questions, and how she reacts to a series of simple tests.

(A number of questions were then put to the patient.)

Notice how little she opens her mouth as she replies to questions. She keeps her mouth open just a little all the time, but when she speaks she opens it only a little more. Notice also the low tone of the voice, its indistinctness and its monotony. And she returns at once to her moaning as soon as the questions cease. You will have noticed also the lack of any evidence of participation, as far as the facial expression is concerned, of her emotional nature as she answers the questions. One would say that she answered almost like an automaton. She gave no sign in her face of any lively interest in the questions, although her answers to them were quite correct.

Q. Do you feel sick now? A. Yes.

Q. Do you ever feel sad, blue, gloomy, depressed? A. Yes.

Her answers are now not especially retarded. When she first came in, however, she was rather slow in answering questions.

Q. Has everybody been good to you in the hospital? A. Yes.

Notice the " ironed-out " appearance of the face, the absence of any " facial mimic," as the French call it. (Fig. 1.)

Q. Have you pain anywhere? A. No, sir.

Now, there is some evidence of emotion visible in the appearance of tears. But even though we have excited an unpleasant feeling here you will observe that there is far less reaction in the face than one would expect. The sudden appearance of tears indicates a strong secretory reaction of the lachrymal glands, out of all proportion to any sadness depicted by the muscles of facial expression.

There is no drooling of saliva at present. Some of these patients have a greatly increased flow of saliva, as well as a greatly increased tear secretion; indeed drooling is a very troublesome phenomenon in many cases. They may even develop sores on the lips and at the angles of the mouth from this symptom and it often becomes necessary to resort to therapeutic measures (atropine; X-rays over salivary glands) to stop the drooling.

She has a firm grip in spite of her emaciation and general appearance of weakness. Responses to command to perform movements are fairly prompt. These patients exhibiting the parkinsonian syndrome, while they manifest but little spontaneity of activity themselves, can often be driven into activity by an energetic request or command. They have a greater ability for motility than is apparent. It is the initiative to spontaneous motor acts that they lack. Members of the family, and sometimes physicians, I am sorry to say, think that the patient *will not* use his muscles; that he could if he but would, and that view of the members of the family seems all the more plausible when they observe that on energetic command the patient can break through the motor stolidity. And yet, spontaneity of motion is, I am convinced, quite beyond the will power of the patient. It is very important both for physicians and families to understand this.

When we attempt to move the limbs passively, distinctly abnormal resistance is encountered; the rigidity in this patient is somewhat less, however, than that commonly present in patients suffering from this malady. It is about equal on the two sides, and it is about as great in the lower extremities as in the upper. Notice, please, the tendency to maintain a position once assumed. The limb goes only very slowly back into the position that it had occupied before dis-

Fig. 1.

The "ironed-out face" of a patient with post-encephalitic parkinsonism.

Fig. 2.
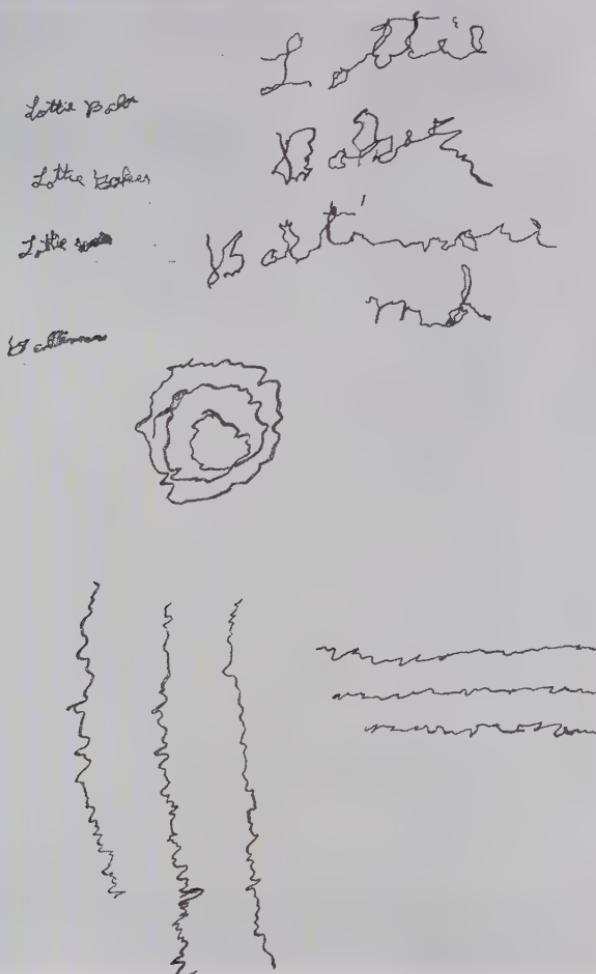
Writing of a patient with post-encephalitic parkinsonism. Note the diminished size of the letters (micrographic) and the evidences of tremor.

placement. Indeed, this rigid state of the post-encephalitic parkinsonian patient has much in common with the cataleptic or with the katatonic rigidity that one sometimes sees in hysteria, or in schizophrenic states.

This point should be borne in mind in attempting differential diagnosis, for schizophrenic katatonia and hysterical catalepsy are often confused with the rigidity occurring as a sequel to epidemic encephalitis. The deep reflexes, though active now, are not greatly increased. There are lively knee-jerks; the Babinski tests have been throughout our observation quite negative. The abdominal reflexes are present, and the pupils react to light and on accommodation, though they are, perhaps, a little sluggish on accommodation. She holds the eyes open when told to close them, a symptom that might be erroneously taken to be evidence of a negativism due to dementia præcox.

She holds the wrists somewhat flexed and the thumbs in apposition to the index and middle fingers. Let us now test for one of the associated movements that is often lost in parkinsonian states. When I make a fist, you observe that there is simultaneously a flexion of my hand on my wrist. When this patient makes a fist her hand does not undergo such dorsal flexion. That indicates that she has suffered a loss of a normal reaction of association of movement. You notice, too, a rather coarse tremor of the hands manifested as she holds her wrists up. Many of these post-encephalitic parkinsonian patients exhibit little or no tremor, in marked contrast with the typical pill-rolling tremor characteristic of the classical paralysis agitans that you are all familiar with. Her coördination is good; the finger-nose test and the heel-knee test are fairly well though slowly carried out. (Fig. 2.)

The profound emaciation visible here is an interesting nutritional phenomenon. The patient is now fifty-six pounds under calculated ideal weight; she weighs only seventy-six pounds, and, as you see, there is an almost entire absence of subcutaneous fat.

In August, 1922, this patient's menstruation stopped abruptly. I forgot to mention that when her appendix was removed the left ovary was also removed. Whether the removal of one ovary had anything to do with the development of this amenorrhœa I do not know; the possibility should, of course, be kept in mind. But with one good ovary left, one would think she should, if healthy otherwise, still

menstruate. It is conceivable, on the other hand, that the amenorrhœa is a part of the metencephalitic syndrome. Endocrine disturbances have been relatively common among the sequelæ of epidemic encephalitis. This patient has a slight thyroid disturbance; though her basal metabolic rate is only increased about 8 per cent. The left half of the thyroid is a little enlarged. We have then to deal with a patient who presents a post-encephalitic parkinsonian syndrome (with loss of facial mimic, poverty of spontaneous movement, rigidity and tremor) associated with peculiar psychic changes, with undernutrition and with mild thyreogenital manifestations.

What is the pathological anatomical basis of a condition such as that observable in this patient? Before we became acquainted with the extrapyramidal motor disturbances that develop after epidemic encephalitis, the Parkinson's disease with which we had long been familiar had been found to be associated with certain remarkable lesions in the ganglia at the base of the brain and especially in the globus pallidus. J. Ramsay Hunt, of New York, and other neuropathologists had made careful studies of these lesions. Neurologists supposed therefore that, at autopsies upon patients dying after parkinson-like sequelæ of epidemic encephalitis, which so closely resemble old-fashioned paralysis agitans, they would find similar if not identical changes in the globus pallidus. Histological studies have, however, been rather surprising in their results. There appear to be more changes in the substantia nigra than in the globus pallidus. In this connection I would refer you to the studies of J. C. McKinley, of Minneapolis (1923), to those of Goldstein (1922), and to those of Foïx and those of Souques in the preceding year. The lesions seem to be due to a diffuse toxic process rather than to local inflammatory foci. It is especially interesting that we seem to deal with lesions of the nuclei and paths nearer the spinal cord than the globus pallidus itself; possibly this explains the deviation of the clinical picture from that of classical paralysis agitans.

If these metencephalitic syndromes are not due to focal inflammatory changes, but are due to diffuse toxic influences, what can be the cause of the latter? Do we have to deal with a toxin produced directly by the virus of epidemic encephalitis? Or has the virus of encephalitis injured some organ of the body and so disturbed its function that

its gives rise to poisons that injure the nuclei and paths of the extra-pyramidal motor system? Of course, one's thought reverts at once to the liver, since in Wilson's disease, in which there are degenerative lesions in the globus pallidus, cirrhosis of the liver is known to be present. Meyer-Bisch and Stern (1922), working on that hypothesis, have studied the liver function in these cases of post-encephalitic Parkinson's disease, and in eleven of them they found an abnormal urobilinuria and in five of them a decreased tolerance for levulose—indications, they believed, of hepatic injury and of a disturbance of liver function. The urine of our patient was examined to-day and Doctor Johnson reports that there is a faint trace of urobilin in the urine but not a large amount, no more than a normal person might at times show. The point is an interesting one. We shall have to await further investigations before we shall know in how far the liver function is disturbed in these cases. In any case, it is well to keep in mind the possibility that we may not have to deal with a primary involvement of the extrapyramidal motor paths in the encephalitic process, but rather with some intoxication depending upon a disorder produced by the virus in some other part of the organism.

Another question of considerable interest in these cases is that of constitutional predisposition. There is, in the first place, the possibility that there may be some constitutional predisposition to infection by the virus of epidemic encephalitis itself. Why is it that the disease picks out only one person here and another there? Great numbers of people have obviously been exposed and have not developed encephalitis; it is a very strange thing that the disease does not often attack people who live together, even in the same family. Doctors and nurses are perhaps a little more often attacked than other people, but not very much more often. Of course, contagion must occur through contact; but why is it that only a very few of those who come into contact with sufferers develop the disease? It would seem that there must be some kind of constitutional predisposition to the disease, but if there were a strong constitutional predisposition (due either to genotypic or paratypic factors) one would expect a greater familial incidence than we see. There is assuredly no marked familial incidence.

Again, of the patients who are attacked by epidemic encephalitis,

only a part develop parkinsonian sequelæ. In those that do develop such sequelæ, we must think of some especial predisposition of the particular centres of the brain concerned to injury, or perhaps of certain toxin-producing organs to involvement. An interesting suggestion in this connection has been made by Villinger (1922). He has adduced some evidence in favor of the view that parkinsonian patients have a constitution of the vegetative type more often than encephalitic patients who remain free of parkinsonian sequelæ. That is a start in the direction of an explanatory constitutional pathology; but again, we shall have to await further data, I think, before we dare arrive at conclusions that are definite.

Studies of constitutional pathology are much in vogue just now. Many articles upon the subject are appearing and the minds of clinicians are being turned in the direction of heredity in the search for etiological explanations to-day more than they have been for centuries. Dr. J. Bauer, of Vienna, will speak at the Baltimore City Medical Society to-morrow night on the relation of the constitution to abnormal endocrine states. He has written an excellent book entitled "Constitutional Disposition to Internal Diseases"—an admirable book and one that will be found very stimulating to anyone interested in these problems. It was written in German and has not yet been translated, though I hope that an edition in English may soon be forthcoming. In this country, physicians are already deeply interested in studies of constitution in relation to disease; I would call your attention particularly to the careful studies now being conducted by Dr. George Draper in the medical clinic of the Presbyterian Hospital in New York City.

Time will scarcely permit me to enter to-day upon a discussion of the differential diagnosis of this post-encephalitic parkinsonian state from other states that it more or less resembles. But let me at least say that very often in making the right diagnosis you have to depend in large part upon the whole history of the case. If you have a history of an earlier doubtful occurrence of an encephalitis in the patient, or of a grippe-like disorder of uncertain nature, the later appearance of a parkinson-like syndrome is very decisive as to the nature of the preceding infection. Furthermore, the mental state of the post-encephalitic parkinsonian patient, though disturbed, repre-

sents a disturbance of an entirely different order from that met with either in hysteria or in dementia præcox. These points are well worthy of lengthy discussion but I must forego such discussion to-day as I desire in the time remaining to call your attention to one or two other important related matters.

One matter of considerable practical importance is that of damage suits in connection with the sequelæ of encephalitis. The Veterans' Bureau in Washington is having trouble with regard to compensation in men who have been in the war and who have since developed a parkinson-like syndrome with disability. I personally have been applied to by several patients and by the doctors of patients, who have asked me if I would be willing to make a deposition stating that, in my opinion, a syndrome like that presented by our patient to-day could be due either to war service or to some trauma experienced in civil life. The patient's friends or relatives were trying to secure compensation either from the Government or some private individual or corporation on the ground that strain of service or injuries contracted had been responsible for the encephalitis or for its sequelæ. The greatest caution should, I think, be exercised when attempting to aid in making decisions as to etiology and as to legal responsibility. One must not only estimate the degree of disability that exists but must also determine, if he can, the true origin of the disability, and the relation, if any, of service in war or in civil life to that origin. Epidemic encephalitis is certainly due to infection with some virus; and probably constitutional factors play some part in disposition to the disease and to its various sequelæ. In how far environmental influences are predisposing, we do not yet know. It may be that the strain of war or that injuries incurred in civil occupation may be of importance as predisposing factors. Certainly, if a patient developed a post-encephalitic parkinsonian syndrome after leaving the war service, and had not had " influenza " during the war, or had not passed through his first stage of encephalitis while he was in the service or very soon afterwards, he would not seem to have any legitimate claim upon the Government for compensation. If he did suffer from " influenza " or from a primary encephalitis while engaged in war service, and as a sequel suffered from an extrapyramidal motor disturbance, the Government should take care of him,

and it is in such cases willing to do so. And in private life, the same considerations might be valid, though I am not yet prepared to say so. Abuses are so likely to develop, that as physicians it behooves us to be very critical and cautious before making positive depositions. The physicians throughout the country are not as yet thoroughly familiar with all the difficulties connected with the diagnosis of these new syndromes or with the principles that should guide those who endeavor to determine liability for damages. In Central Europe the government and military authorities are now referring cases for estimation of disability and for estimation of the origin of that disability in connection with encephalitis and its sequelæ to the University Clinics for expert advice as to decisions because of the experience of the men at work in the clinics with these cases and because of the independence of the men working in such clinics. One cannot help but feel that some such arrangement as this would be a wise provision in America also.

Finally, I desire to refer briefly to the treatment of epidemic encephalitis and of its distressing sequelæ. What can be done to help these patients who so greatly excite our sympathy? Of course, it would be most advantageous if we possessed some specific form of medication—say a reliable chemotherapy—for encephalitis. If we could, in the early stages, administer something that would kill the virus and thus prevent the further development of this terrible disease, we would be very happy. Many remedies have been tried, as you know. One of them is Rosenow's serum. Rosenow has isolated from tonsils, teeth and other sources, in cases of encephalitis, a peculiar coccus; with this, he has immunized horses, and he has injected the immune-serum thus obtained intramuscularly and intravenously in human cases of encephalitis. In acute cases, there have been some reports of improvement after administration of this serum; I have had letters from several physicians to this effect. But it is certainly as yet doubtful whether the coccus isolated by Doctor Rosenow is in reality the casual virus of epidemic encephalitis; and it is possible that the good effects reported may have been instances of spontaneous improvement or of improvement due merely to a foreign-protein therapy. Plain horse serum has been used in the treatment of some encephalitic patients and improvement following its administration

has been reported. Very remarkable remissions are now known to occur in the course of this disease, spontaneously. Unless a newly vaunted therapy should prove to be followed in a large proportion of the cases treated by cure or marked amelioration of symptoms, I should be very skeptical of its significance.

Various attempts have been made to kill the virus in patients suffering from epidemic encephalitis. Salvarsan has been injected without benefit. Mercurochrome, the substance Doctor Young is working with, has, I understand, been tried and will be tried further, though care should be taken not to injure the kidneys. Trypaflavin and various acridin dyes are under test as therapeutic agents, but their real value, if any, in this disease remains to be determined. Von Economo reports benefits from injections of large doses of urotropin in some cases, and of Pregl's solution of iodine in others. But thus far, I think it is quite certain that a successful chemotherapy for epidemic encephalitis has not yet been worked out.

Turning next to the sequelæ, you will ask, is there any effective therapy to which we may resort?

After the parkinsonian syndrome has developed, and the patients are becoming rigid and incapacitated, is there anything we can do in the way of therapeutic intervention that is worth while? Clinicians have observed that, in general, the quicker the parkinsonian syndrome develops after the encephalitis makes its appearance, the greater is the likelihood of recovery; the more slowly it develops, the greater is the probability of permanent residuals and of a progressive course. The first patient with a parkinsonian complication I had, made a complete recovery. This lady developed an outspoken parkinsonian syndrome (with typical rigidity of the muscles and slight tremor) soon after the onset of her encephalitis. With rest and upbuilding measures, the condition cleared up remarkably in the course of six or eight weeks, and later she sent me a report and a photograph that indicated she was perfectly well. Several other patients after treatment extending over several months have markedly improved. Even in the severer cases that at first look hopeless, one should be cautious in denying the impossibility of improvement. Only last month, I saw a patient who was very rigid, so rigid that he could hardly get about at all. Under relatively small doses of hyoscine, rest, massage,

hydrotherapy and general upbuilding measures, he improved greatly and was able to walk much better. I do not believe that he will recover entirely; I fear that there may be progression of the malady later, but certainly symptomatically he is at present better off than he was. In preparing the material for this clinic to-day I ran across a paper by E. Meyer on the atropine treatment of post-encephalitic muscular rigidity. He gave half a milligram of atropine four to six times a day, and states that in a large series of cases he has observed a remarkable improvement. The effects of the atropine wore off, however, after two or three weeks, and the patients relapsed into their former condition. He then adopted the method of giving the atropine for from four to six days, then stopped for from two to four days, and then started in again with the original dosage. He asserts that patients can be kept better indefinitely with this form of atropine treatment. Persons who had been lying about incapacitated became able to get up and do household work. My own experience with atropine therapy has been less gratifying; perhaps I have not pushed the drug as I should have done. But certainly thus far I have secured far better results from the use of hyoscine hydrobromide in doses of from 1/400 to 1/100 of a grain.

If the drooling be very troublesome, and can not be controlled by atropine, it can be stopped by X-ray applications over the parotid glands. In the treatment of sialorrhœa following certain war injuries, it was found that the symptoms could be made to disappear simply by exposing the parotid gland on each side to the X-ray. It is important, of course, not to "kill" the parotid gland but to give just enough of the X-rays to lessen the secretion. Fraenkel (1923) found that four exposures of the parotid gland of each side always in two fields with three-fourths of an erythema dose, given through a 4-mm. layer of aluminum, would always sufficiently check the secretion. He suggests exposures to each gland on two successive days and then waiting a fortnight to see the effects produced before giving any further treatment. Massive doses at a single sitting he expressly warns against.

Finally, let me direct your attention to an interesting paper on the effects of excitation of rhythmical feelings in these patients suffering from late sequelæ of encephalitis lethargica. It has long been known

that in true paralysis agitans (as well as in these post-encephalitic rigidity syndromes) one can temporarily lessen the motor disability by an energetic command to movement or by some emotional shock; under these influences the patient finds that he can do things that in their absence he was incapable of. It is also known that some of these patients can " run " very well, although they cannot walk except with a slow, clumsy, shuffling gait. Certain of the patients can dance, and can ride a bicycle perfectly well, though they cannot perform ordinary movements. It is but little wonder that their behavior seemed paradoxical and that laymen, and sometimes physicians, disbelieved in the reality of the motor disability and declared that the patient was hysterical. That view was, of course, an error. The patients are definitely incapable of doing many things even under the spur of strong emotion with its releases, there still remains marked motor disability. In the paper I referred to, E. Meyer (1923) has reported his observations of the effect of music upon the disturbances of motility in some of these patients. The author found in a number of cases that patients could perform all movements better under the influence of music and of march music. The motor disturbances were made far less troublesome through arousal of rhythmical feelings by music. One may perhaps doubt the practicability of this, but in any event it would seem to be an interesting observation that certain motor difficulties can be, at least to some extent, overcome by stimuli applied in the emotional sphere.

There is scarcely any subject in medical literature about which more is being written to-day than concerning encephalitis and its sequelæ. Only the neurological specialist can be expected to keep track of the whole literature on the subject. The general practitioner must be content to read an occasional collective review of the single articles. He can scarcely do more than to select and read those that promise to throw light upon some case under study. A great deal of detail work is being done to fill up the chinks in our knowledge of epidemic encephalitis, and gradually the complete picture of this very remarkable disease is being portrayed for us. And to the fulness of detail of this picture, *American* clinicians are, I am glad to say, contributing their fair share.

THE NERVOUS AND MENTAL ASPECTS OF ENDOCRINE DYSFUNCTION

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THE relationship existing between the endocrine glands and the nervous system has come to be well recognized by those who have given the subject much study and thought, for it is generally conceded that the ductless glands, in the light of our present knowledge, the thyroid, the pituitary, the adrenals, the thymus and the gonads, especially have much to do with correlative growth of all tissues of the body, including the nervous system. It is also generally accepted that the activity and equilibrium of the vegetative nervous system is dependent upon the endocrine system and that *vice versa* stimulation of the endocrine glands takes place through the vegetative nerves.

THE THYROID

Graves's disease, because of its many nervous manifestations, has been considered by some authorities as neurogenic in origin. " Long before the thyroid or the sympathetic nervous system was emphasized, Geigel, according to Fitzgerald, assumed lesions in the oculopupillary and vasomotor centres of the cervical cord—the former in a state of irritation and the latter in a state of paralysis. Sattler, however, assumed a lesion of a circumscribed portion of the vasomotor centre or possibly a still more central portion of the brain, which presides over the vasomotor nerves of the thyroid gland and of the intra-orbital tissues. * * * This central or *medulla oblongata* theory was strengthened by the experimental work of Filehne, who noted after injury to the restiform body in a rabbit, symptoms suggestive of exophthalmic goitre, namely, tachycardia, goitre and exophthalmus. Moreover, according to Von Leube, an affection of the medulla oblongata as the original cause of Graves's disease is favored by the clinical experience of the nuclear paralysis which has been positively demonstrated in the course of the disease, of the spasms, the paralysis and atrophies of the musculature, the meleturia, etc. In one of Von

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Leube's cases of 'exquisite Graves's disease,' there existed besides spasms, in all four extremities, slight disturbance of the hypoglossal nerve and dysphagia." [1]

However, autopsies on patients succumbing to Graves's disease have shown few positive findings regarding demonstrable changes in the medulla oblongata, and various known affections of the medulla do not produce Graves's disease. Marie and the French school criticized Filehne's conclusions and "considered exophthalmic goitre as a general *neurosis,* and held that while the paroxysmal diarrhœa, the bulimia, the vomiting, anginoid pain, polypnœa, cough and the cutaneous symptoms can all be explained by alteration of the vagus or sympathetic nerves, this is not alone the cause." [2]

Though for a long time affection of the cervical sympathetic ganglion was generally considered as the cause of exophthalmic goitre, authorities differed with this view, notably Murray [3] who believes that the absence of dilatation of the pupil in exophthalmic goitre, the impossibility of continuance of an irritative lesion for years, and the absence of any demonstrated pathological lesion in the sympathetic ganglia in the majority of cases, all militate against the sympathetic nervous system theory. The last objection is weakened by recent experiments at the Mayo Clinic by Wilson [4] who produced lesions in the cervical sympathetic ganglia of nineteen goats by electrical stimulation and direct bacterial inoculation. He concludes that "it would appear that irritation from the presence of certain bacteria within the cervical sympathetic ganglia of the goat may produce histological pictures within the ganglia and in the thyroid, which parallel those found in the various stages of progressive and regressive exophthalmic goitre. The evidence supports the suggestion that in exophthalmic goitre the thyroid receives its stimulus to overfunction through its nerve-supply and as a result usually of a local infection in the cervical sympathetic ganglia."

Whether the theory of auto-intoxication and infection, of thyrogenesis, or neurogenesis, or a combination of these causes ultimately proves to be correct, the fact is apparent that in exophthalmic goitre manifestations relating to the nervous system are prominent and many.

A change in character and temperament is one of the earliest

symptoms, though very exceptionally a patient is encountered who retains his mental poise throughout the course of the disease.

" The frequency of neurasthenic states, of anxiety states and of phobic and obsessional states in patients suffering from the disease is notorious. Indeed, it is on account of the symptoms of such states that the patient most often applies, or is brought by a member of the family, to the physician for relief." [5]

Frankly expressed psychoses, maniacal, melancholic or paranoid, are not uncommon, especially in those with psychopathic heredity. There is evidence favoring a strong hereditary neuropathic influence in exophthalmic goitre which is ably reviewed by Climenko (*Arch. Neur. and Psych.,* May, 1920). Manifestations of nervousness, irritability, aprosexia, headache, insomnia, pressure in the head, hot flushes, and undue fatigability are practically the rule. Behavioristic anomalies are common, as restlessness, hypermotivity and excitability.

In severe myxœdema the nervous and mental manifestations are in direct contrast to those of exophthalmic goitre or of hyperthyroidism without exophthalmos. The psyche of the classical cretin is heavy, listless and apathetic and in acquired myxœdema this condition is also often the distinguishing feature, but such states in varying intensity are not by any means constant concomitants of milder degrees of hypothyroidism. Some hypothyroid children are distinguished by their nervousness and habit of crying and screaming on slight provocation. Thus the hypermotivity and emotivity of the mongolian imbecile is a characteristic of the condition, yet in early life he tolerates comparatively large doses of thyroid with a moderate degree of amelioration of many of his abnormal characteristics. The current impression that the administration of thyroid in mongolism is contra-indicated is due to the fact that the response is not nearly so sudden and dramatic as in definite cretinoid states.

In older hypothyroid individuals the mentality is usually affected to some extent. Inability to concentrate, defective memory and diminished will are early symptoms. The temperament may change from the lively to the taciturn, from self-control to irritability. In severe cases there is often apathy, dulness and depression which may sink into deep melancholia. While mental activity is reduced this

reduction may not be so marked as to interfere with a fair degree of mental attainment, as in a case described by Janney [6] of a man who " had suffered from marked symptoms of hypothyroidism since boyhood, weighing at puberty over two hundred pounds and showing marked physical incapacity. His condition remained undiscovered and untreated until middle life. In spite of this, however, this gentleman became prominent in social, civic and literary circles and was regarded among his friends as a man of unusual mental attainments. Close examination, however, elicited a number of peculiar psychic characteristics ascribable to hypothyroidism, mental instability and restlessness, vacillation, and disturbances in the genital sphere. The basal metabolism was minus 30, in the untreated state. The physical signs were unmistakable. A practical cure was obtained by thyroid therapy."

The relation of hypothyroidism to insanity presents an inviting field for research, as this condition has been suggested by a number of observations as the underlying cause in certain serious psychoses. The frequency of myxœdematous psychosis is differently reported by various authors. Wagner and Jauregg gave a percentage of 15. In a majority of cases the psychosis occurred late, after many years' duration, but in a few cases the psychosis occurred in the beginning of the disease, as reported by Pilcz, Inglish, and Sieran.

The symptoms of the psychosis are not characteristic. Most patients seem to be demented, with more or less delusions, which are not infrequently based on hallucinations. The delusions are apt to be persecutory in character. The tendency to misbelieve is claimed to be one of the characteristics of the disease, and is an important factor in the development of the delusional conditions. Under the influence of their persecutory ideas, patients are apt to become disturbed, cry, become agitated and sometimes extremely violent. In other cases there are reported several different symptoms, such as grandiose ideas, manic exaltations, or melancholia, anxiety and *suicidal* ideas. The latter cases are reported by Pilcz, Kraepelin, Show, Inglish, Beadles, Clouston, Hamilton, McLane and others. Uyematsu,[7] from whom the above several paragraphs are quoted, reports an interesting case of myxœdematous psychosis with *detailed* pathologic findings.

Symptoms relating to the peripheral nervous system occur, true anæsthesias are not frequent though patients may complain of numbness of extremities due to cutaneous infiltration. Paræsthesias, as itching and burning of the skin, sometimes occur, and there exists a diminished irritability to the electric current and a prolonged duration of drug reactions on the autonomic nerves, as the mydriatic action of atropin.

THE PARATHYROIDS

Knowledge of the functions of the *parathyroids* is still somewhat obscure. The two main theories are those of McCallum,[8] who believes that they regulate calcium metabolism in the body, and of Paton,[9] who holds that "the parathyroids control the metabolism of guanidin in the body by preventing its development in undue amounts."

In regard to the manifestation of hyperfunction of the parathyroids comparatively little is known. *Paralysis agitans* has been attributed both to a hypofunction and to a hyperfunction of the parathyroids. Lundborg and Chvostek [10] have suggested that *myasthenia gravis* may be due to hyperparathyroidism, though their view has not obtained general acceptance. Nervousness and insomnia have been observed following parathyroid treatment and Roger Morris has described a psychosis appearing in a woman suffering from paralysis agitans to whom parathyroid substance had been fed over a long period. She became disoriented as to time, indifferent, forgetful, negative, restless, sleepless, irrational and exhibited signs of auditory hallucinations, and loss of sphincter control. Upon interruption of the parathyroid medication and treatment with wet packs, veronal and tincture of nux vomica the mental state began to improve, though seventeen days after stopping the parathyroid medication indefinite signs of tetany spasm appeared which were controlled by calcium lactate and small doses of parathyroid. It is suggested by Morris [11] that there may be fairly definite clinical syndromes that are due to parathyroid intoxication (hyperparathyroidism).

The literature relating to *deficiency* of the parathyroids is voluminous particularly as to the syndrome of tetany which appears, in many cases at least, to bear a definite relation to abolition of, or insufficiency of, the functions of the parathyroid glands. Barker [12]

states: "Why the nervous system should become more excitable when the parathyroid function is deficient is not yet known, though it has been thought probable that, during hypoparathyroidism, some chemical substance (*hypothetical tetany toxin*) that is poisonous to the nervous system develops, or is permitted to accumulate, or remains unneutralized, in the body, and that the tetany syndrome is due to intoxication by this substance." While this interesting condition deserves full description it will suffice for the purposes of this paper to briefly state that the majority of the symptoms and signs in tetany are referable to a hyperexcitability of the nervous system which involves the motor apparatus, the sensory apparatus and the autonomic apparatus. The typical characteristics of tetany consist of [13] "intermittent attacks of tonic contractions with characteristic distribution of the spasms in definite muscular domains, giving the well-known attitudes (obstetrical hand, extended knee with supinated foot, carpopedal spasms) and their association with marked increase of the mechanical and of the electrical excitability of the motor nerves (with low values for the cathodal closure contraction) are marks that scarcely admit of confusion with any other clinical syndrome." But in atypical cases which are frequent, when the tetany is latent and no spontaneous attacks occur, or when tetany is associated with other diseases, or when other diseases which resemble tetany are present, the diagnosis is often a matter of considerable difficulty.

Barker,[14] under the differential diagnosis of tetany, classifies the conditions which may be confused with tetany as follows:

"(1) Conditions (other than tetany) in which hyperkinetic phenomena resembling those of tetany may occur. (*a*) Conditions in which tonic spasms involving the musculature as a whole may occur (tetanus, hydrophobia, strychnine poisoning, katatonia). (*b*) Conditions in which tonic spasms that involve local muscular domains occur (*crampi musculorum*). (*c*) Myoclonias and fibrillary twitchings. (*d*) Tics and habit spasms. (*e*) Conditions in which general convulsive states or fits occur (hysteria, psychasthenia, epilepsy, symptomatic fits).

"(2) Conditions (other than tetany) that may simulate the motor pareses sometimes seen in tetany (poliomyelitis, progressive central muscular atrophy, peripheral neuritis, progressive

muscular dystrophy, myasthenia gravis, and encephalitis and encephalomyelitis).

"(3) Conditions (other than tetany) that may be associated with sensory phenomena resembling those of tetany (acroparæsthesias, arthritides, Raynaud's disease)."

For full discussion of the interesting phenomena of tetany the reader is referred to Barker's comprehensive chapter in " Endocrinology and Metabolism," from which the writer has [15] freely quoted.

THE PITUITARY

Pituitary hyperactivity in its most openly expressed form eventuates in acromegaly which condition is defined by Bassoe [17] as a " morbid state caused by glandular hyperplasia and functional overactivity of the hypophysis, resulting in: (*a*) Primary glandular symptoms consisting mainly of abnormal growth of the soft and bony parts of the ' end segments '—tongue, jaw, hands and feet; (*b*) secondary glandular symptoms from associated and subordinate disturbances of other endocrine glands, notably of the gonads, the adrenals and the thyroid; (*c*) local mechanical pressure symptoms caused by the hypophyseal tumor and affecting chiefly the optic chiasma and nerves; (*d*) secondary and general brain symptoms dependent on increased intracranial pressure."

Sajous,[18] who believes the pituitary to be not a secreting gland but " a coördinating centre which includes, among its functions, that of governing the secretory activity of the adrenals and thyroid apparatus," defines acromegaly as " a disease of nutrition, due to any condition, hyperplasia, neoplasm, etc., of or any pressure upon the pituitary body, capable of primarily exciting abnormally this organ, and then of progressively annulling its functions, and also, therefore, those of the organs it controls, *viz.,* the adrenals and thyroid apparatus, whose combined secretions sustain tissue oxidation, metabolism, and nutrition." He believes that because, according to his theory, of the important relation of the pituitary to the nervous system that its influence in the pathogenesis of general neuroses must be very great, and suggests that acromegaly, which may be attended by irregularity of the reflexes, paræsthesias, localized pains, vasomotor neuroses, paraplegia, etc., known to be due solely to lesions of the pituitary, is a profitable field of study in this connection,

mentioning also, that quite a number of exceptionally able clinicians —Von Recklinghausen, for instance—have considered acromegaly as a trophic neurosis, the organic disease of the pituitary being deemed secondary.

Among the early subjective symptoms referable to the nervous system are headache, pain in the head and face, which constitute a prevailing influence upon the affective life of the patient. There may be sensations, as described from personal experience by Mark,[19] as though the face were in a vise, the antrum tightly packed, the teeth too large for their sockets and the eyes pressed upon; with sensitiveness of the face to light and wind. The headache, deep-seated and splitting in character, is located between the temples and is described by the patient placing a finger on either temple and stating that the headache is within. For a variable time there may be a feeling of increased strength (the asthenic stage) but soon a feeling of lassitude and inaptitude for exertion supervenes (asthenic stage) the first and last stages corresponding, respectively, to the periods of exacerbation of function, and to the period of decline. Mark describes the state into which the acromegalia subsides at intervals as consisting of a feeling of fatigue, as of being partly under an anæsthetic, a desire to keep absolutely still, intolerance of noise and of strong light, dizziness, dyspnœa and loss of interest. Depression may become profound and become suicidal in trend. When the continued enlargement of the pituitary tumor leads to breaking out of its confinement in the sella, the characteristic pituitary type of headache may be relieved, to be replaced later, in the event of continued growth, by the usual brain-tumor headaches, sometimes' accompanied by vomiting, dizziness, and epileptiform attacks. Optic atrophy results from pressure on the neighboring chiasma, with visual impairment and characteristic distortions of the visual field—notably bitemporal hemianopsia. Anosmia may result from involvement of the olfactory bulbs.

Profound deterioration and dementia, as in other cases of intracranial tumor, are not unusual in acromegaly and in their manifestations do not show any characteristics peculiar to the disease. Indeed it is not surprising that in a condition so profoundly affecting practically all physiological processes that aberrant mental states should

occur in the later stages of the disease. The manic-depressive type of psychosis is the one most frequently observed in cases in which deterioration has not fully advanced, and instances have been reported of paranoid states with hallucinations and delusions, though the latter type is uncommon in comparison with states of depression and simple deterioration.

Epileptiform convulsions are not common in acromegaly, especially in the asthenic state, and when present are explained by the increased intracranial pressure. "Uncinate fits" with gustatory auræ may occur especially late in the course of acromegaly, these being more frequent in states of hypopituitarism.

The most important syndrome with prominent nervous and mental symptoms, due to *deficiency* of the *pituitary* is that known as dystrophia adiposogenitalis, which is defined by Beck [20] as " a condition due to underfunction of the hypophysis, characterized by obesity, genital hypoplasia and faulty skeletal development; associated with nervous and mental symptoms which are either the direct result of deficient secretions or dependent upon local or general intracranial pressure."

Headache of the type found in acromegaly is a frequent symptom. Like that often present in acromegaly it is severe, occurs in paroxysms and is described as being located midway between the temples. Frequently it is associated with other symptoms of intracranial pressure, as vertigo, projectile vomiting and visual defects due to optic nerve lesions, as optic atrophy and choked disc. Pressure of tumor mass upon the optic chiasm produces hemianopsia and homonymous hemianopsia. The third cranial nerve may be involved, resulting in external strabismus, or the sixth cranial, producing internal strabismus. Pressure upon the uncinate gyrus produces typical epileptiform seizures with gustatory and olfactory aura.

In the early and milder forms of dystrophia adiposoxexualis, especially those without pressure symptoms, mental symptoms may not be marked or the patient may be dull, apathetic with a low intelligence quotient. In contrast to these is the hyperactive type, superficially bright, talkative, inquisitive, often presenting behavior disorders as stealing, pyromania, etc. In later and advanced cases

the mental state may vary from that of a mild psychosis to definite states of insanity.

Beverly Tucker [21] ascribes to pituitary insufficiency certain psychoses of adolescence which he divides into two groups. In one, the most common, the symptoms resemble those of dementia præcox. Without marked previous symptoms the patients become dull in their studies, seclusive and self-absorbed, unemotional and without affection. Repetition of movements is common and hallucinations and delusions may be present. When disturbed they are obstinate and irritable. Tucker finds in this group thickening and enlargement of the clinoid processes, with a sella of approximately normal size. In the other group the psychosis is not profound. The manifestations consist chiefly of irritability, mental dulness, tardiness, truancy and general lack of ambition, sometimes epileptiform seizures. Röntgenograms show a small crowded fossa. Williams [22] describes a hypophyseal psychosis marked by confusional states and narcolepsy as the chief symptoms. Other psychic manifestations mentioned by Timme [23] are lack of emotional inhibition, highly excitable states alternating with sluggishness, phobias and compulsions and moral and sexual obliquities, all of which characteristics may be modified by pituitary feeding. Mention has been made of the uncinate attacks occurring in tumor affecting the pituitary. Epileptiform attacks without uncinate features occur which are probably due solely to glandular insufficiency (hypoplasia). McKennan, Henninger and Johnston [24] because of the small-roofed sella with enlarged clinoids found in certain cases of epilepsy conclude that the factor concerned is a mechanical one, that the sella by encroaching upon the gland interferes with the normal blood-supply and with physiological activity in consequence of which the animal economy is deprived of those substances produced within the pituitary which are necessary to stimulate normal metabolism.

THE SUPRARENALS

The literature dealing with hyperactivity of the adrenals, in contrast to that concerning itself with hypoactivity, is somewhat scanty. This state has been studied chiefly in connection with tumors of the suprarenal cortex occurring for the most part in children.

The individuals so afflicted sometimes show a marked mental precocity though they may be normal in intelligence, or dull.

In *virilismus,* a condition occurring in women and girls, manifested by hairiness of the face, body and extremities with somatic and genital changes resembling the male, hyperactivity of the adrenals seems to be a factor. The psychic changes in this condition are coincident with the somatic, a physiological result with the added factor of mental stress arising from the effort at adjustment to new conditions, cosmetic, social, etc.

Hirsutismus is a condition also apparently related to disease of the adrenals and is characterized by a growth of hair in unusual places, occurring in women beyond the age of puberty, but with retention of female characteristics. Except for minor character changes due to concern because of cosmetic and social reasons the psyche may be normal, though L. Harris-Liston [25] has reported four instances of this condition occurring in insane women in whom the insanity occurred *first,* and Linser [26] found in the museum of the Royal College of Surgeons a carcinoma (probably hypernephroma) completely replacing the right suprarenal which had been taken from a woman of thirty-two who was maniacal and epileptic. In this connection it may be mentioned that recently ablation of one suprarenal as a cure for epilepsy has been used in Germany supposedly on the theory that epilepsy is due to suprarenal hyperactivity. The results have not been encouraging.

A clear-cut and classical syndrome due to suprarenal deficiency is that first described by Thomas Addison in 1855 and since known as "Addison's disease." In this condition due most often to tuberculosis, atrophy, or neoplasms of the gland the nervous and mental symptoms are marked. Indeed, in the early history of the disease when the suprarenals were commonly regarded as forming an integral part of the sympathetic system, the *nervous theory* of the origin of the disease received wide support. Early in the disease the patient may become apathetic and listless with depression or increased irritability. The intellectual processes are retarded and memory impaired. Sometimes neuralgic pains, paræsthesias and impairment of the special senses occur. Asthenia (adynamia) is the most characteristic and constant symptom of the disease and it involves the

psyche as well as the body, is progressive with possible periods of remission and in the later stages becomes so profound that the patient may become unable to perform the simplest movements. The mental deterioration and psychomotor retardation, which may be the first noticeable signs, may, in extreme cases, amount to a true dementia. Delirium is common in the terminal stages and convulsions sometimes occur.

Hypoadrenia.—Acute suprarenal insufficiency occurring in a variety of conditions may manifest itself chiefly through the nervous system (the nervous type in Lavenson's classification [27]), in convulsions, delirium, coma or in a typhoid state.

Chronic hypoadrenia is common and occurs largely in those individuals with a congenital inferiority of the chromaphil system in whom also there may exist a constitutional inferiority involving not only other endocrine structures but a general somatic inferiority.[28] Although there is considerable disagreement between physiologist and clinician and also among groups of physiologists regarding the functions of the suprarenals and the manifestations of dysfunction, the position in clinical practice and in medical literature of a definite syndrome in which suprarenal insufficiency is the prime factor seems to be well assured. This condition occurs secondary to infections, acute or chronic, to prolonged fatigue, to emotional disturbances, reflex irritation, in fact any condition which serves to abnormally discharge the human battery.

The hypoadrenic individual usually complains of myasthenia and of psychasthenia. Indeed, he shows many of the varied manifestations which have for years been included under the term "neurasthenia," and many of the so-called "neuro-circulatory asthenia" cases of war-time were of this type.

Mott and Hutton [16] have found that, in cases of dementia præcox coming to autopsy, the adrenals were smaller than normal and had a typically thin shrunken appearance, the medulla was distinctly narrowed, the cells were smaller than normal and the cytoplasm much vacuolated and the nuclei smaller and paler; the granules fewer and finer with marked variations in size and shape. In the cortex little change was observed except an increase in fibrous tissue.

THE THYMUS

While in the light of our present knowledge there is no reliable evidence that the thymus possesses a true endocrine function, its physiological and pathological significance being likely due to its lymphoid character, its function being to " supply, through the agency of its lymphocytes, the excess of phosphorus in organic combination which the body, particularly the osseous, nervous, and genital systems, require during its development and growth, *i.e.,* during infancy, childhood, and adolescence or later if need be." [29]

Subinvolution and hyperplasia of the thymus has been considered a causative factor in a number of disease manifestations. Thymic asthma occurs in infancy and is due to mechanical pressure upon the trachea. Mors thymica or sudden death due to thymic hypertrophy has come to be considered not so much the result of mechanical interference with respiration as a manifestation of a generalized status thymicolymphaticus (status hypoplasticus, constitutional inferiority).

These individuals are more predisposed to the development of nervous and mental anomalies than are more normal individuals, in fact, the type of constitution they present is closely allied to the so-called " neuropathological constitution."

Davis [30] examined two groups of soldiers who had been returned from France for the presence of the stigmata of status lymphaticus. Among 114 psychoneurotics, he found 23.68 per cent. of status type, and among 119 cases of battle casualties without psychoneurosis he found the status type is about 12.60 per cent.

Symmers,[31] who has made a deep study of the subject, believes that the syndrome is closely connected and bears a casual relation to the phenomena of anaphylaxis. He states: " It is attended by instability of the lymphoid tissues, providing a mechanism, which, when it is once set in motion, is capable of so sensitizing the body as to produce anaphylactic phenomena varying in intensity from simple urticarial rashes to convulsive seizures and sudden death."

Myasthenia gravis, a disease characterized by marked weakness of the muscular system, due to an exhausted condition of the innervation, without definite pathology in the nervous system but with lymphocytic infiltration in the muscles, seems to be closely connected

with thymic overactivity, thymomata (Ewing [32]) or tumors which are derivatives of embryonic thymic tissue having been demonstrated in a number of cases which have been closely studied.

Aplasia or *hypoplasia* of the thymus seems to be a factor in some cases of mental deficiency. " At the Bicetre Hospital, according to Morel, 75 per cent. of 408 non-myxœdematous idiotic children, ranging from one to five years old, examined *post mortem* from 1890 to 1903, showed absence of the thymus. At the request of Bourneville, Katz performed autopsies in sixty-one mentally normal children, in age from one month to thirteen years, who had died of various diseases. In all these the thymus was present; conversely, in twenty-eight mentally weak children examined by Bourneville, the thymus was absent." [33]

Ludlum and Corson-White [34] report that three out of six cases of dementia præcox which they considered instances of hypothyism were cured by thymus feeding. The uncured cases were very advanced and of long standing.

THE GONADS

In view of the fact that the development and continuance of the secondary sex characteristics, both somatic and psychic, is dependent upon the internal secretions of the sex glands and that the secondary sex characteristics are closely connected with the nervous and mental stability of the individual, it is natural that states of dysfunction should have both immediate and far-reaching results. The hypersexed individual presents numerous problems of social and individual adjustment. Unless endowed with great physical stamina in other respects and adequate emotional control supported by proper moral and ethical considerations he or she is liable not only to debilitating excess, with its consequent train of neuroses, but to actual perversions affecting the psychosexual sphere.

The exaggerated susceptibility to nervous and mental upsets at the time of puberty is well recognized. This phase of the subject is discussed in an article recently published by the writer.[35] The symptoms occurring at the menopause more particularly in females are well known and the hot flashes and heat flushes, vertigo, faintness, cold sensations in hands and feet, the irritability of depression and

in extreme cases, actual psychoses, are present to some extent in a large proportion of individuals at this important epoch.

Hypoplastic conditions in which there is a deficiency of sexual function are so intimately connected with pluriglandular syndromes that they will not be discussed at this time for it has been the writer's purpose in this paper to mention only those conditions in which the symptoms point to a predominate involvement of one gland and only of those which may be considered the most important from the endocrine standpoint.

It is doubtful, however, so intimate is the relationship existing between the various endocrine structures, whether a strictly uniglandular condition exists. For so intimately interrelated and interdependent are the units of the internal glandular system that it is unlikely that any absolutely uniglandular disturbance should exist. However, a discussion of the various pluriglandular syndromes, both those clearly demarcated and otherwise, with their various nervous and mental manifestations, would lead us too far afield for the purpose of this paper.

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Pædiatrics

JAUNDICE AS A SYMPTOM OF DISEASE IN INFANTS AND CHILDREN

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WHILE jaundice is, perhaps, not a specially common symptom in early life, still when we come to inquire into its causes we find that these are very numerous and varied. We shall consider it first as it occurs in the newly born and in early infancy, and then take up its causes as met with in childhood.

I. IN THE NEWLY BORN

A slight icteric tinge of the skin is quite commonly met with during the first week of the infant's separate existence. This occurrence is not by any means easy to explain. It may be due to an infection of the cells of the liver, or to a superabundance of bile-pigment in the young infant. Whatever be the explanation, this symptom should never be lightly regarded, as in some instances it heralds the onset of some serious and often fatal condition. Certainly in such circumstances we always advise very strict attention to the umbilical stump in order to see that it is kept absolutely clean and free from contamination. In more than a few cases we have found the umbilical scar unhealthy looking when called in to see an infant suffering from jaundice, and we have in such cases felt inclined to attribute this symptom to septic absorption from the umbilical stump. At the same time it must be admitted that other causes are possible. The older view was that the bile is carried directly from the liver into the circulation, and in some cases on post-mortem examination the ductus venosus has been found patent. This, of course, would naturally premit of some of the blood from the portal vessels getting directly into the general circulation. On the whole, it is perhaps safer to assume meantime that this early form of jaundice may be due to

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different causes rather than that its origin is constantly the same. These cases usually clear up in a few days without any treatment, except perhaps in those associated with sepsis of the umbilical stump. As a rule there is no icterus of the conjunctivæ, or if affected the coloration is very slight. The urine may or may not contain bile-pigment. In severer cases there may be a tendency to looseness of the stools. In the majority of cases jaundiced infants show loss of weight.

Congenital Stenosis or Obliteration of the Bile-ducts.—This condition always causes marked jaundice. The amount of defect in the ducts varies in different cases. In some all the large ducts are obliterated or absent, while in others only one or more are involved. In a great many of these cases we believe the condition is primarily brought about by inflammatory changes set up during fetal life. A few cases are due to congenital syphilis. Gall-stones have also been found to be the cause in some instances. On post-mortem examination the liver is usually found enlarged and in a condition of more or less marked cirrhosis, while the spleen is likewise increased in size. The jaundice comes on as a rule some time after birth. In one case it was present on the first day, in another it was not noticed until the tenth day after birth, while we believe cases have been recorded in which jaundice did not appear for more than a fortnight. The great characteristic of such jaundice is that it tends to deepen as time goes on. At first it may be scarcely detected, but very soon it becomes more and more distinct. In other cases its depth may vary from time to time. There is always definite icterus of the conjunctivæ, while the stools are clay-colored, and the urine contains bile-pigments. There is definite loss of weight, and the wasting of the rest of the body causes the enlarged abdomen to appear even larger than it is in reality. Hemorrhage is the one complication to be feared in these cases. This may take place from any mucous membrane, such as the stomach, but is much more frequently from the umbilicus. Such hemorrhage is usually rapidly fatal, as infants stand loss of blood very badly. Should hemorrhage not occur, death eventually takes place from inanition brought about by digestive troubles and consequent wasting. In most cases there is no rise of temperature such as we meet with in other severe forms of jaundice. This fact and the

enlargement of liver and spleen in an atrophic infant serve to guide us as to the diagnosis.

Congenital cholelithiasis as a certain cause of jaundice in infants is not very common. Still it does sometimes occur. When gall-stones exist the explanation given of their presence is that they are the product of a fetal inflammatory process. Still refers to their presence. His original article in the *Pathological Society of London's Transactions* for 1899 is well worth referring to for further information on the subject. Gall-stones may cause obstruction of the bile-duct and consequent jaundice. In such cases the stools will be clay-colored and the urine dark in color, so that the napkin is stained a yellowish or greenish-yellow. The jaundice comes on quite suddenly and the infant is restless and irritable, refusing its food. In consequence there is marked loss of weight. The infant obviously suffers considerable pain, as in the case of adults with biliary colic. Such cases are extremely rare, but should not be overlooked on that account.

Congenital syphilis causes jaundice sometimes in quite young infants. It is usually a grave sign when it occurs thus early in life, as it indicates serious disturbance of the viscera. In congenital syphilis the liver may or may not be enlarged. In some cases there is very marked increase in size associated with induration of the organ as a whole. This is indicative of grave implication, and is always to be regarded as giving a very bad prognosis. On the other hand in a great many cases the enlargement is slight, and under treatment disappears entirely. Even in serious cases associated with great hepatic enlargement and induration the jaundice is rarely of an unduly intense character.

Congenital Cirrhosis of the Liver.—This condition may be the result of syphilitic heredity. This is of the nature of a biliary cirrhosis, and the liver is definitely enlarged with marked interstitial tissue deposit. Apart from syphilis the cirrhosis may result from pathological changes in the bile-ducts which may be induced by inflammatory processes occurring during fetal life. In all such rare cases icterus is the inevitable result, and naturally the prognosis is exceedingly bad.

Buhl's disease is a somewhat curious condition. In this we find acute fatty degeneration occurring. Very often, in such cases, the

infant is born asphyxiated, and after it recovers develops hemorrhages from various mucous membranes, especially from the stomach and intestines, but also from the umbilicus. Petechial hemorrhages also make their appearance on the skin. Sooner or later the infant becomes œdematous and jaundice makes its appearance. On post-mortem examination fatty degeneration of all the organs is found. In particular the liver is atrophied and bile-stained. Blood extravasations are found in the stomach, intestines, kidneys, and it may be in other organs. The post-mortem appearance suggests that the cause of the disease is a toxin of some kind. Probably it is the result of septic infection of the umbilical stump. Cases of this disease, however, are too rare to enable us to say more regarding its nature and causation, though it has to be borne in mind as a possible cause of jaundice in the young infant.

Winckel's Disease.—This disease shows a definite tripod of symptoms, *viz.,* cyanosis, jaundice, and hemoglobinuria. On the third or fourth day after birth the infant becomes markedly cyanosed. This cyanosis involves not only the face, but the entire body including the arms and the legs. Jaundice is the next symptom to develop, and in some cases this is intensely marked. Hemoglobinuria is always present. Death occurs extremely rapidly, and is ushered in by drowsiness, and it may be by convulsions. Hemorrhages are found post-mortem in all the internal organs, but unlike Buhl's disease the degenerative changes in the liver, kidneys and heart are by no means marked. The disease appears at times to occur in small epidemics. Various organisms have been isolated from the blood by different observers, but nothing definite is really known as to the causation of the disease.

Miscellaneous conditions may simply be mentioned as likely to cause jaundice in the newly born. There appears to be an epidemic form in which the jaundice has been so deep that it almost amounts to a bronzing of the skin. In some of these cases the presence of the bacillus coli has been demonstrated. Many of these cases have symptoms closely related to those of Winckel's disease, and may indeed be forms of it. Thus several observers have independently described a disease known as bronzed icterus, in which there are jaundice, vomiting, convulsions, and dark-colored urine. Then there is the form of jaundice not infrequently met with soon after birth in which death

usually results. This form of jaundice occurs in succeeding infants in one family. There are often associated cerebral symptoms, and it is sometimes combined with umbilical and intestinal hemorrhages. The cause is not readily defined. It looks as if this were but merely some interference with normal development or the result of septic infection. It is, however, impossible with our present lack of knowledge to dogmatize on the subject.

II. IN INFANCY AND CHILDHOOD

Here we have to consider quite a number of conditions, some of which are undoubtedly rare in young children, but are nevertheless of great importance. Many of them differ from the conditions met with in the newly born in one respect, namely, that they are amenable to treatment, and consequently their diagnosis is of first moment.

Catarrhal Jaundice.—This is by far the commonest form of jaundice encountered in early life. Under this heading we prefer to consider merely that variety which is secondary to gastroduodenal catarrh. This is generally set up by some food which has disagreed, although in some instances it may be due to cold. The first evidence is an upset of the stomach characterized by gastric symptoms such as vomiting. Presently the catarrh spreads to the duodenum so that the orifice of the common bile-duct gets blocked up by inflammation of the duodenal mucous membrane. The inflammation extends, and the result is that the bile cannot find an exit by the natural channels. Starting with gastric discomfort or even actual pain in the epigastrium, and sickness or actual vomiting, jaundice very soon developed. In daylight this is often first detected in the conjunctivæ, but sooner or later the whole skin surface becomes tinged. There is apt to be constipation, and the stools have a pale, clay color owing to the absence of bile. On the other hand the urine is dark, and on examination is found to contain bile-pigment and bile-acids. The pulse is often slow, but may be rapid, and the child is usually somewhat drowsy and lethargic. A very troublesome feature in many cases is itching of the skin, while lichen urticatus may be an irritating complication. There may be a slight degree of fever. On examination marked tenderness can be made out at and round about the epigastrium, while the liver may be found slightly enlarged.

The diagnosis of catarrhal jaundice is usually a comparatively simple matter. The shortness of its duration, with the history of an immediately preceding gastric catarrh, generally suffices. At the same time we must be careful not to mistake its causation for some more serious condition which may be present. The prognosis is good, and recovery the rule. At the same time the jaundice may continue for some weeks, especially if the treatment is not rigidly and properly undertaken.

As regards the treatment of this form of jaundice, diet is the first essential. As practically no bile reaches the intestine, fats are the articles of food which cause most trouble. These are badly digested. The diet should, therefore, at first consist of milk from which the cream has been removed, diluted with soda or Vichy water, and farinaceous puddings such as farola, ground rice or tapioca. Well-boiled oat flour and milk or one of the infant foods may be given. Later fish, chicken, and meat are allowed, while soups (free from fat) or a meat essence are also a pleasant change. Eggs, butter, and every form of fat must be rigidly excluded from the diet. The patient must be kept warm in bed. Drugs have a certain value. The most useful are those which combat the gastroduodenal catarrh and so free the bile-ducts. Best of all are powders consisting of small doses of bismuth, soda and rhubarb. The compound decoction of aloes is sometimes beneficial, and so is the well-known gray powder. The patient should be encouraged to drink plenty of alkaline water, and for this purpose we consider soda or Vichy water best.

Obstruction of the Bile-ducts.—This may be produced by the pressure of gall-stones, enlarged abdominal glands in tuberculous disease, or by round worms lodged in the ducts. The jaundice present in such cases often gives little clue as to the real cause at work, though there is always marked pain in the epigastrium and the usual clay-colored stools and bile-stained urine. Vomiting is likewise here an early symptom. In some cases death occurs without a diagnosis having been made as to the true condition present, and treatment must often be as in cases of catarrhal jaundice. Doubtless in some cases the X-rays may prove helpful in clearing up the diagnosis, but very often they fail to throw any light on the case. A round worm or worms in the bile-ducts is by no means an uncommon occurrence, and

should always be thought of in such otherwise obscure cases of jaundice occurring in children.

Congestion of the Liver.—This is met with in disease of the heart or respiratory organs. It may also occur in certain of the exanthemata. The organ is enlarged, and assumes the characteristic nutmeg appearance. The symptoms include jaundice which may be general or only specially marked in the conjunctivæ. The stools are pale in color. The tongue is coated, and vomiting is frequently present. Diarrhœa is sometimes observed, and there is always more or less interference with digestion. Pain in the region of the stomach and liver is usually complained of, and there may be a certain degree of fever present. Ascites may develop, and give rise to enlargement of the abdomen with distension of the veins on its surface. On examination palpation detects at once the definite lower border of the enlarged liver. Recovery will depend largely on the cause at work in producing the hepatic congestion. In fevers the congestion generally disappears very soon, but in heart and respiratory cases the congestion may remain for quite a long time, although with improvement in the causal condition the circulation may become reëstablishd and the liver return to normal once more. In the simpler form such as results from fevers, magnesium sulphate or sodium sulphate gives good results. In the more severe type the heart or respiratory condition must first be dealt with. Here, again, saline purgatives are invaluable. For the pain, which is frequently a troublesome symptom, hot fomentations or mustard and linseed poultices are beneficial.

Cirrhosis of the Liver.—This may undoubtedly be congenital. Apart from this variety we have a definite alcoholic type first as in the adult, and a malarial form, while the syphilitic variety is well recognized. While alcohol, malaria, and syphilis are undoubtedly the commonest causes of hepatic cirrhosis in early life, other causes are occasionally operative. Thus it may follow upon long-standing congestion of the organ, especially in heart and respiratory disease. Then there has been described a form of biliary cirrhosis very much like that which we meet with in adult life. In the alcoholic variety the liver surface is nodular, exactly like that of the well-known "hobnailed" polylobular cirrhosis of gin-drinkers. As a rule the symptoms presented are exactly similar to those met with under similar

conditions in later life, and include gastro-intestinal disturbances, hemorrhages, jaundice, and it may be ascites and œdema of the lower extremities. Abdominal pain and progressive loss of weight are practically always two of the most prominent symptoms, while rise of temperature with coma or convulsions may mark the terminal stage. The prognosis is not very good, although recovery undoubtedly does take place under prolonged treatment in certain of the milder cases. This is perhaps specially true of the malarial cases of hepatic cirrhosis.

The patient should be kept warm in bed as a rule, and the diet strictly attended to. Milk free from fat or a milk-diet is usually found most suitable. To this may be added, by way of variety, meat juice, soups, fish, and chicken. Bismuth, soda and rhubarb powders will improve digestion, and salines are also indicated. The late Sir Thomas Fraser used to be fond of two drugs in hepatic cirrhosis in adults, and they are also of value in the case of children. These are potassium iodide (we prefer sodium iodide which is less likely to upset the stomach) and ammonium chloride. The latter, he maintained, had the effect of stimulating the liver-cells. Personally we have seen temporary improvement follow the adoption of this line of treatment, but unfortunately we have never met with an ultimate recovery.

In the syphilitic variety we have found a combination of hydrargyrum cum creta with syrupus ferri iodidi very helpful. Inunction of mercurial ointment we do not recommend, although it apppears to be still used by some physicians. Later we are fond of giving two or three minim doses of the old-fashioned Donovan's solution, *viz.,* liquor arsenii et hydrargyri iodidi, a remedy which we find has become almost forgotten save by the older school of clinicians. Finally sulpharsenol may be injected intramuscularly in suitable cases. The malarial form demands no special treatment beyond that of the condition causing it, and quinine with or without arsenic will be found most generally beneficial.

Suppurative Pylephlebitis.—This is a rare disease. The term indicates a suppurative inflammation of the portal vein. It may be due in infancy to infection of the umbilical stump, and in later childhood to suppurative conditions in any of the organs drained by the portal system. Vomiting is often an early symptom, and this may

soon be followed by looseness of the bowels. The temperature is swinging, and signs are common. Profuse perspiration and abdominal pain are always marked, and jaundice supervenes sooner or later. The end is usually ushered in by coma. This condition is necessarily a fatal one, and treatment resolves itself into relieving the pain by hot fomentations or linseed poultices, and keeping the patient on milk.

Abscess of the Liver.—This is a very rare condition in the child. It may undoubtedly be due to traumatism, while suppurative inflammation of the portal vein may lead to it. It may be part of a general infection in cases of pyæmia, while the presence of round worms in the biliary passages may cause it. Other causes may in some cases be operative, but these appear to be the principal ones. The symptoms are by no means characteristic, and consequently the diagnosis may remain uncertain. Rise of temperature, discomfort or pain over the liver with perhaps some enlargement of the organ and, in some cases, vomiting constitute the group of symptoms observed in most patients. Sometimes a definite local swelling in the liver can be made out on palpation of the organ, which is usually exceedingly sensitive to pressure. In abscess of the liver *jaundice is certainly not a constant feature,* although it does occur in some cases. Pleurisy is by no means a rare complication. Recovery without operation is somewhat uncertain, and the death-rate is necessarily high. Much depends on early diagnosis and prompt operative interference. The treatment is of necessity surgical in every case. Aspiration or free incision and drainage of the abscess may be employed for its relief.

Hydatid Cyst of the Liver.—The cystic stage of the intestinal parasite known as the *Tænia echinococcus* occurs in the human subject who becomes infected by the ova voided by the dog or wolf in the intestine of which the adult parasite finds a resting-place. Hydatid cyst of the liver is certainly met with in the child. The liver in such cases becomes enlarged and painful. The right lobe is most commonly the situation in which the cyst develops. As a rule jaundice and vomiting are complained of, and there may be distinct loss of weight. A hydatid thrill can often be detected on palpation over the tumor. Very frequently there is a rise of temperature, and there may be considerable abdominal distension. The dangers are: (1) Rupture of the cyst into the pleural or peritoneal cavity, and (2) suppuration.

Hydatid cyst of the liver is very often fatal, although it is said that cure may result by the cyst undergoing a degenerative change by which it becomes hard and calcareous. Generally speaking, unless operative interference is undertaken, cure is not likely to result. The results of operation, however, are on the whole hopeful, and if complications have not supervened, the prognosis after operation is very favorable in most cases.

Tumors of the Liver.—Apart from abscess and cyst of the liver, carcinoma and sarcoma are met with in children. On the whole it would appear that carcinoma of the liver is by no means uncommon in early life. Sarcoma is probably rarer. Jaundice, which may be entirely absent, is rarely marked. The most constant single symptom is perhaps pain over the liver, while the chief sign is abdominal enlargement. On palpation and percussion the liver is found to be considerably increased in size. Wasting, gastro-intestinal disturbance and some rise of temperature are usually noted. Once the condition makes itself evident the duration is very short, a few months at most, while in the case of a sarcomatous involvement of the liver the child may only live for a few weeks.

Fevers.—Jaundice occurs in the course of certain of the fevers as a complication. We have already referred to malaria as a fever affecting the liver. It may certainly be a cause of jaundice, as may also typhoid and paratyphoid fever, influenza, typhus fever, septicæmia and pyæmia, and yellow fever. With the exception of the last-mentioned disease in which, of course, jaundice is a cardinal symptom, the occurrence of this is an indication of considerable gravity. The patient should receive a stimulating treatment, thus maintaining his strength, and attacking the jaundice as in the simple catarrhal form. *Hemoglobinuria* is a condition which is sometimes associated with jaundice, but it is certainly a rare affection in children, and need only be mentioned in this connection.

Acute Yellow Atrophy of the Liver.—Although this is altogether a rare disease, it appears from the literature that it may be encountered even in children. As to its etiology we are pretty safe in assuming that it is toxic in origin, and I personally strongly suspect the *bacillus coli communis* as being the causal organism in these cases. The condition may or may not be preceded by one or more attacks of

what appear to be ordinary catarrhal jaundice. Finally an attack of jaundice sets in with vomiting and headache, tenderness over the liver and a rise in temperature. As time goes on the liver is found to shrink very considerably and head symptoms, pretty much like those of meningitis, develop. Thus we have sensitiveness to light or photophobia, delirium passing into coma or very often convulsions. Like meningitis, too, the pulse is slow at the beginning, becoming very rapid towards the end. Death usually results, but recovery has, it appears, been recorded. This, however, is doubtful.

Weil's Disease.—This disease is also known as epidemic jaundice, ictero-hemorrhagic fever, and as icterus hemorrhagica spirochætosis. It is undoubtedly caused by the *Spirochæta ictero-hemorrhagica* of Inada. Guinea-pigs, when inoculated, were found to show symptoms of jaundice and albuminuria as well as hemorrhages. The jaundice came on within seven days. Cultures of this organism grow best at a lower temperature than 37° C., and in fact Inada claims that the best temperature is somewhere between 22° and 25° C. The disease is certainly a highly infectious one, although children are not so often affected as adults. The incubation period varies from five to seven days. For the first two or three days the temperature continues to rise. For the next three days there is developed a definite yellow coloration of the skin and mucous membranes. Hemorrhages also occur under the skin and from mucous surfaces. In this respect Weil's disease resembles very closely yellow fever in which jaundice and hemorrhages are characteristic. In fact it was at one time supposed that the two diseases were related in some way to each other. During this period the liver and spleen become swollen and more or less enlarged. Following on this the temperature begins to fall and improvement takes place. The jaundice generally lasts for about a week. At the end of about a fortnight, in cases which recover, convalescence begins to set in. The jaundice lessens, the hemorrhages cease, but the patient is left in a prostrated and anæmic state. There is more or less marked wasting present, and the heart's action is extremely feeble. During the convalescent stage the spirochætes entirely disappear from the blood, but are found, however, in the kidneys and urine.

It has been practically proved that the disease is transmitted by

the urine of rats, and possibly of mice, which contains the infecting spirochæte. Once humans become infected they can pass on the disease by the urine which, as we have seen, contains abundant spirochætes during the convalescent stage, and this would therefore appear to be the most dangerous period as regards the possibilities of spreading the disease to others. An antiserum has been prepared, and this has already been used with a certain degree of success in cases of Weil's disease. Preventive measures, however, are of greater value than any active treatment and consist in the wholesale destruction of rats, the strict isolation of patients, and in particular the most thorough disinfection of their urine, while under treatment.

Poisons.—Lastly, jaundice may be due to certain poisons such as phosphorus, mercury, arsenic, chlorate of potash, and liquid chloroform. In poisoning by certain fungi jaundice is quite a definite feature of the case. It may also be met with where castor oil has been administered after santoninum or filix mas, thereby causing absorption and toxic symptoms. In most of these cases the condition met with after death is acute fatty degeneration of the liver. In santonin poisoning coma and convulsions often come on before death, and hemoglobinuria may be present. Nausea, vomiting and epigastric distress are usually the first evidences of impending danger. A case has been placed on record in which 0.12 gram proved fatal in a boy of five and a half years. In poisoning by chlorate of potash we find very dark-colored urine, containing albumin, but sometimes the urine is entirely suppressed. In such cases the icterus has a remarkable color, not exactly yellow, but more of a brownish-yellow shade or even deeper. Poisoning by fungi is usually brought about by mistaking for edible mushrooms some really poisonous fungi. The symptoms produced are, as a general rule, abdominal pain, vomiting, diarrhœa, intense thirst, cold clammy perspiration, feeble pulse, and the usual evidences of collapse. Jaundice is often present in such cases. Symptoms usually appear within twelve to twenty-four hours, and death may occur within forty-eight hours. The fatal termination may be preceded by delirium and convulsive seizures.

It will be readily gathered from what has been said that icterus is by no means an unimportant symptom in infancy and childhood. In infancy especially it is to be regarded as suspicious of some abnor-

mal condition, except in those cases of so-called "mild icterus" occurring in the newly born, and which generally disappears in a very short time. Attention should always be paid to the umbilical stump as this is a very common portal of entrance for septic organisms such as the *streptococcus, staphylococcus,* and the *bacillus coli.* We have always maintained that too great care cannot be taken of the umbilical stump. The scissors with which it is cut should previously be thoroughly sterilized. After cutting, the end should be covered with corrosive wool. After bathing the infant the cut surface should be dressed as any other wound would be, and not merely wrapped up in a piece of linen or ordinary cotton-wool. Absolute alcohol makes a good dressing, and has much to recommend it. In children with jaundice the cause should be carefully sought for in every case, and care taken not to dismiss as merely catarrhal a case of jaundice due to some grave disorder. An etiological diagnosis is not always possible, but careful investigation of every case is imperative even if, after all, little can be done for those in which some serious lesion exists. It must never be forgotten that even in children such conditions as cancer, sarcoma, cirrhosis and acute yellow atrophy of the liver may be met with, and that jaundice may be due to these.

Finally, reference may be made to the question of the so-called cholagogues which are so often used in the treatment of jaundice. These were at one time supposed to increase the biliary secretion. They may certainly increase its excretion in some instances by hurrying it along the intestinal canal, and in this way prevent its reabsorption. The only true cholagogue, however, is oxbile, which occurs in the " U. S. Pharmacopœia " as *Fel Bovis Purificatum* [*Fel Bovinum Purificatum.* B. P.]. It is best given in pill form, and the dose is 0.3 to 1 gram (5 to 15 grains). It is by increasing the excretion of bile that the so-called cholagogues are of value in cases of jaundice. The best examples of such action are calomel, and the preparations of mercury generally. Certain organic substances have also a definite value in this direction, such as podophyllin, enonymin, and iridin. Salines may also be regarded with favor as aiding the action of mercurials, consequently we often prescribe magnesium or sodium sulphate or sodium phosphate as an after-purgative in cases where calomel has been ordered.

POLIOMYELITIS *

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WE have here a couple of little children whom I want to show you to-day. I have brought them in at the same time, because, as far as I can see, although very different in their symptoms, they are suffering from the same disease. Take, first, the little boy here, whom I saw with a physician in the city on the 30th of October, the child having been seen by him for the first time the day before. In response to my inquiry as to his diagnosis, he told me that it seemed to him to be meningitis. The history which I obtained during my visit was to the effect that the child was three years old, and had previously been well until taken ill about four weeks before. The rest of the history was difficult to obtain, on account of the lack of intelligence of the parents; but it would seem that the child had fever and was so ill that he was taken to a hospital, and the diagnosis of pneumonia was made there. In four days he was discharged as convalescent. All this seems strange, and I feel that there must be a mistake in some of the data. We do not know certainly that the diagnosis of a pneumonia was made. At any rate the boy had a cough, and continued to have this on his return to his home. Recently he is said to have developed stiffness and pain on passive movement in the back of his neck and in his legs, especially the left. There has been no vomiting; no delirium; no twitching or convulsions, and apparently no disturbance at all of his mental state. I remarked at the time this history was obtained that it did not sound like that of meningitis, so far as the mental condition was concerned, although the stiffness in the neck and legs was very suggestive of this.

My examination showed him to be, as you see, a well-nourished child. His mind seemed perfectly clear. There were no general symptoms suggesting meningitis. He had a great many scattered

râles in his chest but no consolidation was found. Now here came the interesting thing. When I went to lift the back of his head from the pillow, the whole trunk lifted with the effort, and yet I could roll the head from side to side perfectly well. This is exactly the sort of rigid neck seen in meningitis. I then tried to move his legs, but I found that it gave him severe pain, especially when the left leg was handled, and that he held them stiffly in position. It seemed at first as though there was pain at the hip-joint, and yet there was no restriction of movement here, as would be shown by any fixation of the pelvis. Then I sat him up in bed, and that evidently gave him intense pain, and he resisted strongly. There was, in fact, a very striking picture of an excessively painful rigidity all over the body. There was no swelling, no redness, and no restricted movement in any of the joints; the stiffness and pain seeming to be in the muscles. As the child could not be properly cared for at his home, we sent him to the hospital here for further study and treatment.

For the first couple of days in the ward he had a little elevation of temperature to 100°, but since that time he has been practically afebrile. Our examination duplicated that which I have given you, and I will add only a few further details. The blood showed an absence of leucocytosis or any other noteworthy change. Lumbar puncture gave a clear fluid under increased pressure, with a positive sugar-reaction, a negative one for globulin, and with 144 white cells to the cubic millimetre, 120 of these being lymphocytes. The knee-jerks were absent.

He has improved very decidedly in the ten days of his stay with us, but you still observe the rigidity and the pain when he is handled. He also exhibits a very important symptom, which had been overlooked previously, but which I noticed on my first examination of him, and have deferred mentioning to you until now. You will observe, namely, that when I give the soles of his feet a sudden, sharp prick with a pin, he cries out but does not draw his feet out of the way at all. Cannot he do so, or is he unwilling because of the pain which movement produces? I think you may properly conclude that when a child is thus pricked sharply and suddenly, the withdrawal of his feet will in most cases take place involuntarily, and he forgets for the moment the possibility that this movement will cause pain

elsewhere. I think we may feel pretty sure that this boy is unable to move his feet.

What diagnosis are we justified in making? We may practically omit the consideration of encephalitis. He has never exhibited any characteristic symptoms of this disease. The increase in the cells of the spinal fluid and the rigidity of the neck strongly point to meningitis. On the other hand, either an acute meningitis or one of a tuberculous nature should by this time have produced some very positive symptoms of one or the other of these diseases. We do not know just how long he has been suffering from his present disorder, but he has been sick in some way for now over five weeks, and meningitis of any kind would certainly before this have given rise to some cerebral symptoms such as unconsciousness, delirium, convulsions, and the like. Before now in ordinary cases of poliomyelitis he ought to have had a disappearance of the pain and tenderness to a considerable degree, and the persistence of such marked rigidity of the neck is unusual. Yet there is such a variation in the symptoms of poliomyelitis that I think no other diagnosis is justifiable; and this is borne out by the condition of the spinal fluid. He has, in fact, just such a fluid as you often find in either one of the two diseases, poliomyelitis and tuberculous meningitis.

Before I turn from the case let me impress upon you the salient features which I want you especially to remember in connection with it. These are the uncertain onset with symptoms uncharacteristic except that there was fever and respiratory involvement, and, in the second place, a most unusual degree of stiffness and pain, the stiffness being a voluntary resistance, not a spastic state.

This other child, which I now show you, is a little girl of three years, who was referred to me by a physician on November 1st. She was said to have been entirely well until three weeks ago, except that for a few days before she developed her present trouble she had had a slight cold, lost her appetite to some extent, and began to be rather irritable. That was all. Nothing at all of any moment; but please note the existence of the slight respiratory symptoms. After these few days of such symptoms, which did not confine her to bed, she was walking down the stairs when the right leg suddenly gave way, and she has shown a decided limp ever since. She has com-

plained frequently of a moderate amount of pain about the knee, yet not sufficient to prevent her from walking or to make her cry. She was seen by her physician who made a tentative diagnosis of scurvy, situated in the neighborhood of the ankle. Accordingly she was sent to the X-ray department of one of the hospitals of Philadelphia, but nothing was found wrong in this region of the body. Then her parents took her to another physician who thought at first that she had poliomyelitis but later wavered and suggested hip-joint disease. Finally she was brought to obtain an opinion from me. I eliminated scurvy at once. The child was three years old, decidedly beyond the age when infantile scurvy is usually seen, unless there had been some special dietetic cause to produce it. There was none here. She had had a mixed diet and had been daily given orange juice. In fact the symptoms did not to my mind present the slightest suggestion of scurvy. My examination showed the child to be in good general condition and with a good color. She walked distinctly unsteadily, yet uncharacteristically, the limp being apparently due to trouble somewhere in her right leg, the nature of which was not clear. She had some subjective complaint of pain here, but there was no pain or restriction of passive movement at the hip-joint or elsewhere. The gluteal folds appeared to be exactly alike when the child was standing. The knee-jerks were present on both sides. I want you to pay particular attention to this last. As far as I could discover she did not present any positive indications of hip-joint disease. I told the family very frankly that I could not tell just what was wrong and that we needed an X-ray study of her hip, and especially to have the electrical reactions tested in the affected leg. It was for this reason that she was sent to us here. Personally I believed that the disease was poliomyelitis.

I ought to say in this connection that on the day following her visit to me a telephonic message reached me from the father, to the effect that the neighbors reported that the child had had a fall a few weeks before the evidences of paralysis appeared. In this fall she seemed to have hurt her right leg quite badly and could not at first get up, but later in the day used the leg without any difficulty. This complicated the diagnosis still further. It was perfectly possible that we were dealing merely with a sprain of some sort.

She has been in the hospital now about a week. An X-ray examination was made and showed nothing discoverable wrong with the hips or elsewhere. The Department for Nervous Diseases has tested her electrically and finds the reaction of degeneration present in the muscles of the right leg. That, I think, settles the diagnosis. The case is clearly one of poliomyelitis. Let us get her out of bed and see how she walks. She does it with less stiffness and awkwardness than she did a week ago, but you see the gait is becoming distinctly characteristic; that is to say, she is beginning now to " throw " her foot in a way seen in poliomyelitis. Her knee-jerks are still present on both sides, perhaps a little less developed on the affected one. As yet there is no atrophy of any moment visible.

How different the history of this child is from the ordinary history of the disease, and how different these two cases are the one from the other; and yet, as I said, both are instances of the same affection.

I wish we had time to study carefully the symptoms of this disease, but we must limit ourselves largely to certain features which are illustrated in these two cases. First, as you know, in the course of a poliomyelitis, comes the prodromal stage, lasting from three to four days. There are hyperæsthesia, irritability, fever, restlessness, and perhaps vomiting; just such symptoms as you might find ushering in any acute disorder, especially those of a digestive nature. In very many cases respiratory symptoms are present, such as cough, coryza, and bronchitis, and including sore throat. You will notice that in both of our patients there was a disturbance of this kind. But as a rule there is nothing characteristic in the prodromal stage of poliomyelitis, and the paralysis comes on without anyone knowing it, not even the physician. That was the way it was in our first case. Don't let it happen to you as it did here, that some other physician is called in and discovers a paralysis which you have overlooked. It may be perfectly excusable, but it is hard to make the family believe it. Nobody knows how long this child has had paralysis of his legs, but it is likely that it had existed for quite a considerable time.

The other case, the little girl, illustrates a condition occasionally seen, i.e., one in which the onset of the paralysis seems to be absolutely sudden in the midst of almost perfect health. There are plenty

of cases on record like this. The child has perhaps been playing about, sits down for a while, and then cannot get up; or it has been put to bed in the evening apparently entirely well and is found paralyzed in the morning. In nearly all such cases it is probable that there had been prodromal symptoms, so insignificant that they had been overlooked. In the case of our little girl we know that there had been a little irritability and slight respiratory disturbance; and perhaps fever would have been found if one had taken the temperature. These cases of sudden paralysis may be very misleading, as they were in this instance. The parents naturally seek for some fall or accident of other kind; and what child is not having such accidents every little while? The element of coincidence is often forgotten. We have to be very careful in making a diagnosis. I could tell you many tales to illustrate this. Take, for instance, the pseudo-paralysis of scurvy. I saw a little child some years ago, one younger than this, who was lying in bed in the early morning beside its father. The father was asleep, and in his sleep he threw out his arm and struck the child. The child, of course, cried vigorously, and when they took it up then or later they found it unable to move its right arm. They brought it to me, the father filled with remorse because he thought he had hurt his own child. He naturally did not take into account this element of coincidence. What had occurred was that the child had developed infantile scurvy, a perfectly clear case, but it happened to show its symptoms for the first time just then. I could go on telling you of other cases. A little child fell on his younger baby sister, and the infant was supposed to have been injured by this fall. Nothing of the kind. It was found to have scurvy. I speak of these merely to show you that you must not be too quick in assigning to slight trauma, troubles involving pain or disturbances of movement.

After the stage of invasion is past we have the stage of acute paralysis, in which the loss of power increases for a short period. Pain on movement continues during this time, and is liable to persist to some degree after other general symptoms subside. This stage of acute paralysis lasts usually less than a week, and is then followed by the stationary stage, and later by that of retrogression of the

paralysis, and finally the chronic atrophic stage. We need not discuss these here. Our two cases are still too acute to make it necessary.

The case of our little boy was, as I said, peculiar in the long continuance and the severity of the pain. This leads me to speak for a moment of some of the different forms of poliomyelitis. There are many classifications, and their only use is for convenience of study. Wickman, the well-known Scandinavian authority on the subject, describes eight classes. I wish to refer to but two of these. The first is that called the meningitic type. In this the symptoms are almost indistinguishable from those of acute meningitis. In addition to the cerebral symptoms the rigidity in the back and neck and throughout the body is very decided, and there is hyperæsthesia and pain on movement. In the case of our little boy-patient the early diagnosis of meningitis had been made. The absence of the other symptoms of this disease, however, excluded its presence. The other variety is a rare form, the polyneuritic type. This is characterized by the unusual severity and persistence of pain and tenderness in the nerve-trunks and the muscles. The limbs are held rigid in order to guard against movement, and the paralysis may be entirely overlooked. There are no cerebral symptoms. I would not go so far as to call this case an undoubted instance of the polyneuritic type. We can, however, conclude that it strikingly resembles it in some particulars. Certainly I do not recall seeing a case showing such a degree and long continuance of painful rigidity as this boy exhibits.

I neglected to refer to one of the symptoms of poliomyelitis, namely, the disappearance of the knee-jerks. Usually these are much diminished or oftener lost in the stage of invasion or of acute paralysis. In the case of our little girl, however, you will find the tendon-reflexes present, although a little less marked upon the paralyzed side. We can explain this only on the ground that the paralysis in this case is but slight; not enough to cause a complete loss of the patellar reflex. This does not militate in any way against the diagnosis.

Lack of time prevents our considering the diagnosis of poliomyelitis in detail. We have already discussed it in part. If we could only have reason to suspect the oncoming of the disease, we could often diagnose it in the prodromal stage by an examination of the

spinal fluid. This shows an increase in the number of cells; very early the polymorphonuclear predominating, soon the lymphocytes. The fluid is similar to that seen in tuberculous meningitis. A very few days' observation, however, will distinguish the two diseases. The trouble is that, except in epidemics, there is nothing to suggest the importance of a lumbar puncture, which obviously cannot be performed on every child with acute febrile symptoms.

Cerebrospinal fever sometimes causes confusion on account of the meningitic symptoms which may occur in some forms of poliomyelitis. A lumbar puncture, however, gives a fluid absolutely different from that of the latter disease, revealing a purulent fluid with a big increase of the polymorphonuclear cells. An examination of the blood reveals a leucocytosis with an increase of the polymorphonuclear cells. I have alluded to scurvy. On account of the pain there seems in this disease to be a paralysis; and I have seen a mistake in diagnosis happen repeatedly. But the history of scurvy is so entirely different, both in its onset and in its associated symptoms, that if you give it serious consideration you can hardly make a mistake. You can settle your diagnosis in any event by the therapeutic test of orange juice.

Another disease causing confusion is rickets, not in the acute stage of poliomyelitis but later. The mistake in diagnosis is often made, and I have seen cases even in hospital practice where surgeons have pronounced a case poliomyelitis and where it has turned out to be only the pseudo-paralysis of rickets. A rachitic child may be so feeble that it does not move its legs, or moves them very slightly. An electrical examination will settle the diagnosis; but this is really seldom needed. Then there is the possibility of confounding poliomyelitis with other forms of paralysis seen in infancy and childhood. Obstetrical paralysis has such a different history, that of its occurrence at birth, that it can hardly be mistaken, although the reaction of degeneration is found in both conditions. Infantile cerebral paralysis should, as a rule, cause no difficulty. Not only is the history entirely different, but we have in it the element of spasticity, which is not to be confounded with the contractions seen about a joint in old cases of poliomyelitis. It is only in the rare instances of poliomyelitis of the acute encephalitic type that

we find a spastic condition present. Finally there is epidemic encephalitis. There is no trouble whatever in diagnosis as a rule. The question could not arise in either of our two cases. But it must be admitted that between this disease and some of the cases of poliomyelitis of the bulbar type diagnosis may be impossible. We had just such a case in this hospital a year or so ago, which left us without a positive diagnosis having been made.

Prognosis and treatment we can mention only briefly. As to the former, in the acute encephalitic and meningitic forms the death-rate is high. However, a case of any type which has lived two weeks will probably recover so far as life is concerned. In the spinal cases it is impossible early to make a prognosis as to the degree of paralysis which will remain. Even a case with wide-spread severe early paralysis may recover entirely. The majority, however, will always show some degree of paralysis remaining in certain regions; how much we cannot tell. If there is an early return of faradic contractility the prognosis is good. If after two or three months there is much atrophy and entire loss of the contractility, the prognosis for recovery of power is not good. One thing, however, we have learned during and since our great epidemic; and that is that there is almost no time, except in the very old cases, when you cannot look for some degree of improvement under treatment.

As to treatment, I can say only this. Don't hurry it up. You do not want any massage or electricity while the hyperæsthesia persists. It will do more harm than good. All you can do is to watch out against deformities. You will begin soon to have the foot drawn down, and you must use an apparatus to keep it up. If you allow the child to sit up too soon, you begin soon to find scoliosis developing. So don't hurry them. We should give these children much longer rest than we used to do. Then when the proper time comes, electricity, massage, and efforts at voluntary movement will help. The discussion of the best means for the prevention of deformity is something for the orthopœdic surgeon, and I will not touch upon it further.

Surgery

RECENT ADVANCES IN SURGERY

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ANÆSTHESIA

LUCKHARDT and Carter are responsible for introducing ethylene to the profession, and it has already been used in a sufficient number of cases to demonstrate beyond any doubt that it possesses many advantages and will probably occupy an important place in anæsthesia in the future. Its properties have been known for many years; it may have been used as early as 1849, but the evidence is by no means conclusive. In 1874, 1876, and 1885 there are records showing that its anæsthetic properties were known, but these were only demonstrated experimentally. Apparently it was not used again until 1919 when Luckhardt and Thompson demonstrated not only its anæsthetic but its analgesic properties, and in 1923 Luckhardt and Carter reported 106 cases in which it had been used as a general anæsthetic in various operations.

Ethylene is used in combination with oxygen in a ratio of about 90 to 10. Pre-operative medication with morphine, scopolamine, and so forth, is not necessary, but has the same advantage and indications as with other anæsthetics. The advantages of the anæsthetic which have been pointed out by Luckhardt and Lewis and confirmed by others are: First, the ease of induction and rapidity of recovery; second, relaxation without cyanosis; third, absence of sweating; fourth, absence of respiratory irritation; and fifth, narrow anæsthetic margin.

The absence of struggling and excitement under this anæsthetic is very striking. Although induction is rapid, better relaxation is obtained if a few moments are allowed for the thorough saturation

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of the patient with the anæsthetic.   When anæsthesia has been induced, respiration becomes regular and somewhat shallow; it is neither grunting in character nor forced.   The regular natural respiration is one of the striking features of ethylene anæsthesia.

The ease of induction makes the ethylene-ether sequence preferable to the nitrous-oxide-ether sequence, and patients appear to take ether after ethylene with less irritation than after nitrous oxide. The patient rapidly recovers from the anæsthetic even after prolonged anæsthesia.   After serious abdominal operations, lasting for an hour or even longer, patients will be completely conscious before leaving the operating room; they seldom vomit, and if they do, it is not protracted, and there is a noticeable absence of headache or post-anæsthetic distress.

Relaxation is much greater with ethylene than with nitrous oxide, and it can be secured without cyanosis.   As a matter of fact, the patient's color is abnormally pink, and bleeding from superficial vessels is apparently more active than it is under ether anæsthesia.   This is not an objection, however, because if bleeding is controlled under these circumstances, hemostasis should be absolute.

The absence of sweating is very noticeable, and dry skin is an exceedingly important factor, particularly in operations in the upper abdomen.   The absence of respiratory irritation is most definite, and excessive secretion of mucus, as occasionally occurs with ether anæsthesia, is rarely if ever seen with ethylene.   For this reason pulmonary complications are unquestionably less common after ethylene anæsthesia than after ether.

A further advantage is the narrow anæsthetic margin.   This is particularly of value in thyroid surgery, for example, when it is important to have the patient conscious during certain stages of the operation in order that injuries to the recurrent laryngeal nerve can be avoided and hemostasis made absolute.

Luckhardt and Lewis speak of three possible disadvantages of ethylene: (1) Its odor, (2) its explosibility, and (3) the oozing from the wound.   The odor is not a real objection and, as a matter of fact, is much less than that of ether.   The explosibility is a danger, but ether vapor is also explosive, and surgeons have become acquainted with its dangers and their prevention.   While Luckhardt and Lewis

admit that the oozing from the wound may be greater, it is certainly not excessive.

The most useful way in which ethylene oxygen can be employed, particularly in abdominal operations, is in combination with ether. A small amount of ether, about 4 to 6 per cent., will usually give satisfactory relaxation for opening and exploring of the abdomen. During the greater part of the operation the ether can be cut down to 2 per cent. or even less, and then increased, as necessary, for the closing of the incision. In the short time that ethylene has been employed it has been shown, without question, that it has distinct advantages, and there seems little doubt that in the future it will supplant many general anæsthetics.

THE GALL-BLADDER

There has been a reaction against cholecystectomy for certain pathologic conditions of the gall-bladder, common duct, and pancreas. In a symposium on the surgery of the common duct before the surgical section of the Royal Society of Medicine in 1923, it was emphasized by Mayo, Moynihan, Sherren, Walton, and Turner that relief from pressure is the first and most important point to be accomplished in obstructions of the common duct. This involved the question of the indications for cholecystostomy and cholecystectomy, and it was the general impression that it would be safer in certain cases of common duct obstruction and acute infections of the liver, gall-bladder, biliary tract, and pancreas, to drain the gall-bladder rather than to remove it. The pre-operative preparation of jaundiced patients by intravenous calcium has proved of great value.

SURGERY OF THE STOMACH

In the field of surgery of the stomach one of the interesting features of the last year has been the visit of Finsterer to this country, during which time he performed a number of operations under splanchnic anæsthesia. Such advanced methods of local anæsthesia are usually European, and their development is probably due to the methods of general anæsthesia used in European countries. It is doubtful if American surgeons will obtain better results with this type of anæsthesia than with a properly administered general anæsthesia, particularly the ethylene-oxygen-ether combination.

Finsterer is an ardent advocate of local anæsthesia in gastric surgery. For the abdominal incision he employs what he terms " conductive anæsthesia of the abdominal wall," while for the intra-abdominal part of the operation his choice is splanchnic anæsthesia. He has found that he obtains better results by radical operation in cases of ulcer than he formerly obtained by gastro-enterostomy. When the latter was the operation of choice his percentage of cures was 62, but with his more extensive operation he reports cures in 90 per cent., and, in many of the 10 per cent. which he includes under unsatisfactory results, the patients suffered from other diseases, such as ventral hernia or gall-stones. As a rule he resects the duodenum and two-thirds of the stomach. In cases of extensive perforations of the ulcer, in which the common duct is involved in the ulcer base, he prefers what he terms " the operation of duodenal exclusion." He lays particular emphasis on certain technical points: (1) The line of incision in the stomach should be oblique to the axis of the stomach and roughly parallel to the axis of the body; (2) only the lower half of the gastric incision should be used in the end-to-side gastrojejunostomy; and (3) the ascending loop of jejunum must not be too short to fasten high enough on the wall of the stomach to act as a patch. All of these factors play an important part in the prevention of what Finsterer describes as " retrograde filling of the duodenum "; the entrance of food into the remaining portion of the duodenum and stomach leads to the formation of secretin which results in increased flow of hydrochloric acid, and possibly the formation of jejunal ulcer. If an ulcer of the lesser curvature penetrates into the pancreas, he advises resection of the ulcer so that its base is left on the pancreas; then drainage with a rubber tube. If there has been acute perforation, he advocates suture with gastro-enterostomy or resection. For hemorrhage he advises early operation before anæmia has become so severe that the operative risk is greatly increased, and he prefers resection to gastro-enterostomy.

Another contribution to operations on the stomach, from a technical standpoint, has been that of Haberer, who introduced a new type of gastroduodenostomy which has recently been described in this country by Finney. This is a method of reconstructing the continuity of the gastro-intestinal tract after resection of the pyloric end of the

stomach, by implanting the end of the stomach into the side of the duodenum. The method may be applicable in certain cases, but probably not often.

RENAL FLUOROSCOPY

Braasch and Carman discuss the value of renal fluoroscopy at the operating table. Its chief advantages are in: (1) Determining the presence of renal stone in cases in which röntgenograms, cystoscopy and urography fail to identify a doubtful shadow, (2) determining the exact localization of the stone in the kidney, and (3) insuring the removal of all stones, particularly if the shadows in the röntgenogram are multiple.

The röntgenogram cannot be absolutely relied on with regard to the number of stones, or their position. In a recent review [5] of 1061 cases of renal lithiasis in which operation was performed at the Mayo Clinic, it was noted that: (1) A single shadow was seen in the röntgenogram and multiple stones were found at operation in 146 cases; (2) multiple shadows were seen in the röntgenogram and a single stone was found at operation in sixty-six cases; (3) no shadows were seen in the röntgenogram, and one or more stones were found at operation in twenty-one cases; and (4) shadows were seen which indicated stones in the upper ureter, but the stones were found in the kidney, not in the ureter, in five cases. It is self-evident that if the fluoroscope discloses but one stone shadow, the surgeon will not spend a great deal of time, or damage the kidney, in searching for more. It is equally evident that, with multiple shadows in the fluoroscope, much unnecessary destruction of renal tissue may result from the search for other stones when only one is present.

In the removal of irregularly shaped stones, a fragment may easily be broken off without the surgeon's knowledge. In about 10 per cent. of the cases the examination is not satisfactory because of fixation by adhesions, a short pedicle, or an anomaly. Very small fragments of stones may be overlooked, but the total percentage of error has been 1.2.

The technical details are of great importance, including the advantageous position of the kidney, the preparation of the röntgenologist's eyes, and the absolute darkening of the room.

Recently Quinby has suggested a method of insuring complete

removal of stones from the kidney by means of röntgenograms made at the operating table, by placing small protected films in direct apposition to the exposed kidney. By means of a rapid developing process, it is claimed that these films can be read three or four minutes after exposure.

LUGOL'S SOLUTION

Plummer and Boothby report the results of the use of Lugol's solution in exophthalmic goitre, showing the course of the metabolic rate, the pulse-rate, and the weight of the patients before and after the administration of the drug. The average dose has been ten drops daily, and if the drug is not tolerated by mouth, it is given in similar doses by rectum. Approximately 600 patients with exophthalmic goitre were treated with Lugol's solution, and none with unquestioned exophthalmic goitre was made worse by it. Thirty-seven per cent. improved markedly and promptly after the administration, 32 per cent. definitely, 26 per cent. only slightly, and 5 per cent. were not affected. Since its use the pre-operative mortality rate has been reduced, and the surgical mortality rate and the frequency of the typical post-operative hyperthyroid reaction resulting in death has, as shown by Pemberton, progressively decreased.

URINARY RETENTION

In the surgical treatment of the hypertrophied prostate, one of the causes of mortality has been the sudden emptying of an overdistended bladder. The sudden reduction of intravesical pressure results in congestion throughout the urinary tract with resulting œdema and hemorrhage, and, owing to the fact that the renal capsule is a limiting inelastic membrane, this œdema raises the interparenchymal pressure sufficiently to interfere with the blood-supply of the glomeruli and tubules, thus preventing the excretion of urine and the urinary constituents.

Bumpus and Foulds have recently reviewed 100 cases of urinary retention in which they employed the von Zwalenburg method of gradual emptying of the overdistended bladder. Briefly, the method is as follows: A soft rubber catheter with a clamp on the distal end is fastened into the urethra. The clamp prevents loss of any of the contents of the bladder, and the possibility of renal congestion is thus avoided. The catheter is connected to a water system which includes

a manometer and drains into a receptacle. Under this arrangement, urine will drain into the receptacle only when intravesical pressure is raised on deep inspiration, and so the whole urinary tract will continue to function under its usual tension. The advantages of the method are: (1) Prevention of sudden renal congestion with consequent interference with urinary output; (2) rendering more remote the possibility of infection due to renal congestion and repeated catheterization; and (3) the avoidance of a sudden drop in blood-pressure, which, as shown by O'Connor, follows sudden emptying of the bladder, by diminishing the drop and extending it over a much longer period. The method was used preparatory to one-stage and two-stage prostatectomies. It was also used in cases of carcinoma of the prostate with retention in which metastasis could be demonstrated and operation avoided, and in cases of stricture of the urethra.

The authors kept careful records of the systolic and diastolic blood-pressure, of the intake and output of fluids, and of the intravesical tension. From a consideration of these data they conclude that " the critical point is at the time the blood-pressure has reached its lowest point, and the longer the fall of blood-pressure is delayed, the greater the amount of urine secreted, and the more rapid the fall in blood urea content; also, conversely, if at the period of minimal blood-pressure the urinary output has also markedly decreased and the urea is rising, the prognosis is very grave." The mortality in this series of patients was 2 per cent.

THE RÖNTGENOLOGIC DIAGNOSIS OF CHOLECYSTIC DISEASE

In the diagnosis of lesions of the stomach and duodenum, probably no single factor gives as much aid to the internist as does the opinion of an experienced röntgenologist. It was, therefore, natural that röntgenologists should early have turned their attention to lesions of the biliary tract. In 1900 Beck first recognized a shadow thrown by a gall-stone. George and Leonard in 1917 first demonstrated a shadow which they considered to be due to a pathologic condition of the gall-bladder, and the continued interest of George, Leonard, Barnham, and Kirkland has resulted in the recognition of what they term " indirect evidence of cholecystic disease." The importance of these improvements in röntgenologic technic may be realized by the following: At the Mayo Clinic 5 per cent. of all patients registered

have been given a clinical diagnosis of cholecystitis, and 64 per cent. of the last hundred necropsies revealed microscopic evidence of inflammation of the gall-bladder. In order to estimate properly the value of röntgenologic examination of the gall-bladder, relying on direct signs only for their diagnosis, Carman, MacCarty, and Camp have made a study of 2500 cases in which they have compared the clinical diagnosis, the X-ray report, and the surgical findings. From this study they recommend the use of contact films, and in the reading of the films they emphasize the importance of differentiating the shadows thrown by the liver and the right kidney. A third shadow between the tenth rib and iliac crest may represent the gall-bladder, but they mention fourteen other causes for shadows in this region. Further clinical investigation may be necessary in order to determine the exact cause in a particular case. In the discussion of the cause of the shadow thrown by the gall-bladder, the authors mention that there are other factors besides thickness of the wall of the gall-bladder and viscosity of the bile, and they believe that the evidence from indirect signs is very unreliable. The indirect signs most frequently looked for are: (1) Deformities of the antrum of the stomach, duodenal cap, and second portion of the duodenum, supposedly produced by a distended gall-bladder, and (2) deformities of the pyloric end of the stomach, duodenum, and hepatic flexure, produced by adhesions between these structures and the gall-bladder. However, surgical statistical investigations show that the gall-bladder is distended in less than 10 per cent. of the cases, and, in 1743 cases of cholecystitis in which careful surgical observations were made concerning adhesions around the gall-bladder, it was found that they were present in only about 30 per cent. of the cases, and that they varied from a thin fibrous band to a dense fibrous mass. From the röntgenologist's viewpoint, adhesions dense enough to deform or displace the duodenum or hepatic flexure are rare. George and Leonard hold that deformities due to adhesions are most marked when the stomach and duodenum are full. Therefore, they should not be overlooked during fluoroscopic examination. In a series of 538 cases, however, in which a diagnosis of duodenal ulcer had been made, and which subsequently came to operation, only eleven, a 2 per cent. error, failed to show an ulcer. The cause of the deformity in these cases proved to be disease of the

gall-bladder with adhesions to the duodenum. A review of Carman and MacCarty's findings shows that gall-stones were diagnosed correctly in 38.4 per cent. of the cases, the highest percentage thus far reported, and in 17.4 per cent. of the cases they made a correct negative diagnosis. A correct positive diagnosis of cholecystitis without stones was made in 45.5 per cent. of the cases. They conclude that an affirmative X-ray diagnosis is highly valuable, but that it can be made only in the minority of cases; they hold that a negative report is worthless.

Graham and Cole have approached the problem of X-ray diagnosis of cholecystic disease from an entirely different standpoint. They realized the enormous value of substances opaque to the X-ray in the diagnosis of lesions of the duodenum and stomach, and sought a substance which, on administration subcutaneously, intravenously, or orally, will be secreted in the bile in sufficient concentration to produce an outline of the gall-bladder. They had previously noticed that certain dyes, for example tetrachlorphenolphthalein and rose bengol, are secreted almost entirely in the bile. Other considerations suggested the use of the calcium salt tetrachlorphenolphthalein, which they have found to throw clear-cut shadows of the gall-bladder in experimental animals and in human subjects. They recommend its use in doses of 0.1 gram for each kilogram of body-weight, and thus far 6 grams is the largest dose they have administered to a patient. They now use the following method: 6 grams of tetrachlorphenolphthalein is mixed with 1.2 grams of calcium hydroxide, ground in a mortar with a few cubic centimetres of water, and dissolved in 325 to 350 c.c. of distilled water. To this, 2 grams of calcium lactate are added. The solution is sterilized by bringing it to the boiling point over a flame, and heating it in a water bath at 95 to 100° for fifteen minutes. It is then filtered and administered slowly, intravenously (from 20 to 25 minutes). The method gives definite and clear-cut shadows of the gall-bladder, both in experimental animals and in human subjects, and no untoward effects have been observed in human subjects with the concentrations used. The report is only a preliminary one, and the authors do not draw any conclusions as to what should be interpreted as a normal shadow and what should be interpreted as an abnormal one.

ACTINOMYCOSIS OF THE HEAD AND NECK

New and Figi have recently emphasized the frequency with which actinomycosis is not considered as a causative factor in lesions of the head and neck. In a series of 157 cases of actinomycosis, 107 involved the head and neck, and only seven of the patients had received treatment prior to their examination at the Mayo Clinic. After a study of these cases the authors hold that the mode of infection is not by direct contagion from lower animals, but rather by trauma from some infected foreign body, such as a blade of grass or a seed of cereal, or that infection is secondary to invasion of a traumatized area by organisms that were in the mouth previously.

The lesion may vary from a small nodule to extensive involvement of the neck, indistinguishable from an acute phlegmon, depending on the virulence of the infection and the amount of secondary infection. The most common picture is of an indurated mass which later breaks down, developing multiple superficial abscesses with many sinuses.

The diagnosis depends on the clinical picture, the finding of sulphur granules, and the microscopic examination. New and Figi assert that sulphur bodies can usually be easily recognized if a fresh pocket is opened, and if the sulphur body is immediately examined under the microscope, the actinomycosis may be demonstrated. As regards treatment, they emphasize the importance of early diagnosis, and recommend a saturated solution of potassium iodide by mouth up to 200 drops a day, opening up widely all pockets and packing daily with iodoform gauze, the wound being swabbed with tincture of iodine. They have found 3000 to 6000 millicurie hours of radium, using 2 mm. of lead screening and 2.5 cm. of wood distance, valuable in those cases which present a hard and indurated mass with no fluctuant areas or sinuses.

SALIVARY UREA INDEX

Hench and Aldrich have directed attention to the value of the salivary urea index in the diagnosis and management of cases of urea retention. They have shown a close parallel between blood and salivary urea, although this parallel is not constant, since the salivary urea rapidly hydrolyzes into ammonium carbonate. For this reason they use what they term the " combined salivary nitrogen " as the salivary

urea index. This close parallelism has a practical application, as saliva may be used for the determination of urea. The method has the advantages that saliva is easy to collect, and the necessity for repeated venipunctures is avoided. For the determination of the salivary urea index, the authors adopted a modification of the Friedlander method for the determination of urea in the urine. From estimations on 190 normal persons, they have fixed a normal salivary index at between 30 and 50, and have shown that the salivary urea index increases in definite parallelism with urea retention, as evidenced by the blood urea. The method is particularly suitable for bedside use by the general practitioner who has no laboratory facilities. The authors have shown, however, that, if immediate estimation is not possible, the bringing of the saliva to the boiling point will kill the ammonia-forming bacteria of the mouth, and will not otherwise interfere with the accuracy of the estimation of the salivary urea index.

INTRAVENOUS THERAPY

Since the days of Lister, one of the aims of the study of medicine has been to find an antiseptic which would be destructive to bacteria and yet not injurious to the body-cells. Since protoplasm is the basis of all living matter, such a selective action must, in the end, be qualitative rather than quantitative. During and since the war, much effort has been expended in seeking such an antiseptic. Browning and his co-workers in Middlesex Hospital, London, who were particularly interested in finding an antiseptic suitable for use in the treatment of wounds under war conditions, finally favored the flavin group, particularly acriflavin and proflavin. After further experimental work, they found proflavin to be more suitable for intravenous treatment. In this country, Young, Churchman, Davis, and White, seeking an antiseptic which would be effective in urinary infections, looked for a solution of the problem from a synthetic point of view. They tried the effect of numerous dyes which were made up of molecules, some of which had a selective action on the kidneys, others exerting a germicidal action. As an outcome of the combined work of these and other workers, the possibility of certain dyes acting effectively in septicæmia on intravenous injections is now seriously considered. Three dyes have been advocated for this purpose: Pro-

flavin by Browning, mercurochrome by Young and others, and gentian violet by Churchman.

An antiseptic, to be suitable for intravenous use, must be non-toxic to the body tissues in a dilution which will still maintain its bacteriostatic action, and non-irritating to the organs of the body, particularly the kidneys, by which most of these dyes are excreted. It must not agglutinate the erythrocytes, or inhibit the phagocytic activity of the lymphocytes. It should be antiseptic in high dilution, and it must not enter into combination with the proteins of serum, whether this combination is a physical one of absorption, or a formation of a true chemical compound; in other words, its antiseptic action in serum should be equal to, or greater than, that which it possesses in a watery medium. Browning and Galbransen showed that proflavin (diamino-acridine sulphate) possessed these properties when given in doses of 0.15 to 3 grams (in the form of 1:1000 solution in physiologic salt solution), while Piper and Young have recently reported the favorable action of mercurochrome (dibrom-oxymercury-fluorescein) in cases of puerpural septicæmia and septicæmia following infections of the urinary tract.

Hill and Colston, after having studied the effect of mercurochrome on the bacteriostatic action of the blood, report that this action is increased and that the increase is greatest in the fifteen to forty-five minutes following the injection, after which it disappears rapidly. They have also shown that the urine became bacteriostatic about five hours after the injection, and that this inhibitory action did not increase *pari passu* with increased dosage, for with high dosages there is marked diarrhœa and intestinal elimination of the drug. From this it is seen that mercurochrome is a substance which is bactericidal, or at least bacteriostatic, on intravenous injection, and which also is a true internal urinary antiseptic.

Experimental studies have been made on the amount of mercurochrome tolerated for each kilogram of body-weight by different animals, and, from a consideration of these, the human dosage has been decided. Piper, in his five reported cases, used from 5 to 8 mg. for each kilogram of body-weight, while Young, in his seven cases, used 1 to 8 mg. for each kilogram of body-weight. These authors emphasize the importance of using a freshly prepared solution, and advise

against the use of the drug unless the solution is clear. In the first
hour following injection the patient vomits; this is followed in less
than two hours by diarrhœa. Within six hours a mild chill will prob-
ably occur, followed by a rise in temperature, and then a gradual
decrease, with a proportional decrease in pulse-rate until the tempera-
ture reaches subnormal. The diarrhœa may continue for a day or two
and may be severe enough to require treatment. Churchman has
advocated the use of gentian violet intravenously. He notes the
parallel between organisms to which gentian violet is bactericidal and
those which are Gram-positive, but thus far has not definitely proved
whether this can be explained chemically. Gentian violet is, there-
fore, particularly suitable in cases of septicæmia in which staphy-
lococcus is the invading organism. He directs attention to the cyanosis
which immediately follows the injection of the drug and is due to
staining the tissues by the dye. The blood of the injected animal has
been shown to possess the selective bacteriostatic property of the dye
itself, but only for a short time. This property is really due to the
presence of the dye, and is partly destroyed as the blood enters into
combination with the different organs, yet most is lost by oxidation
or reduction of the dye itself. The dye is used in a 1 per cent. solu-
tion, and from 4 to 8 mg. are given for each kilogram of body-weight.

HERNIA

The literature on hernia is very extensive, but the repeated
attempts to secure a satisfactory method of treatment show that none
has been entirely successful. The large number of hernias operated
on during the war afforded a unique opportunity for study of the late
results in patients who were otherwise in physical prime. Gallie and
Le Mesurier, and many other surgeons, were surprised to learn of
the large number of recurrences in this group, even in cases in which
the surgery was known to be above reproach. Their findings stimu-
lated them to inquire into the causes for such failure, with the result
that they have contributed what appears to be a real advance in the
technic of operation for hernia. Their animal experiments demon-
strated that, when fascia was sewn to fascia, there was no real union
between the layers proper, but that the union was through the thin
layer of areolar tissue which covered the fascia or aponeurosis. This
line of union was seen, on microscopic section, to have none of the

histologic structure of tendon or fascia, there being entire absence of
the parallel arrangement of fibrous bundles which one would expect
to find in aponeurotic structures, but the fibres were interlaced in all
directions, as in a real tissue, of which the scar was in reality com-
posed.   In experiments in which the animals were allowed to live
longer after operation, the scar of the line of union was shown to
have stretched, thus allowing the re-formation of the weak area of
the abdominal wall, with the possibility of recurrence of the hernia.
Their experiments showed that this stretching of the scar was more
likely to take place if absorbable sutures were used, and to a lesser
degree if non-absorbable material was used for the sutures.

They were convinced that recurrence was always a possibility
with the accepted methods of treatment, and, therefore, applied their
method of living tendon grafts to the treatment of hernia.   They had
previously shown that tendon grafts preserved their vitality when
transferred to other regions of the body, apparently securing nutri-
ment by osmosis from the surrounding lymph.   The stages of the
operation, so far as the anatomic union of the layers is concerned, are
similar to the old methods, except that tendon is used instead of cat-
gut or silk for suturing.   They emphasize the importance of anchoring
the tendon suture in an unyielding tissue, such as the rectus sheath,
employing enough of the suture to withstand the anticipated strain,
completely filling the gap when the edges cannot be drawn together.
This is better than drawing the edges under great tension (darning).
They also demonstrated, by tension experiments on the graft, that it
neither stretched nor contracted.   The graft was taken from the fascia
lata in strips about 0.5 cm. wide and 22.5 cm. long.   The use of a
needle with a large eye to make the threading easier, and tying of the
ends of the fascial strip to prevent splitting is advocated.   The
authors are more than pleased with results, some of which they have
observed for four years from the time of operation, with no sign
of recurrence.

SHOCK

One of the unsolved problems of medicine is the cause and pre-
vention of shock.   As not infrequently happens, we have reached
further in our knowledge of its prevention than in our understanding
of its causation.   One has but to review in passing the various theories

that have been offered for its explanation, for example, the vasomotor exhaustion of Crile and Mummery, the acapnia theory of Yandell Henderson, the inhibitory theory of Multzer, the coloric theory of Kinnamim, and the embolic theory of Bissell, to realize that it is not because solutions have not been sought, but because of the difficulty of the problem that it has not been solved.

Crile has recently offered a physico-chemical basis for the phenomena of shock in which he regards the body as a structure composed of an enormous number of electrical cells arranged in groups which we know as organs. Each cell of the body he considers electrical, with the nucleus the point of higher potential, the cytoplasm that of the lower. He believes there is a corresponding difference of potential between the different organs of the body, holding that the potential of the brain is highest, that of the liver lowest. The nerves he regards as the connecting wires between the different organs, and the salts dissolved in body fluids as the electrolytic fluid by which the electro-chemical mechanism is made. On the basis of a disturbance of these electro-chemical arrangements, Crile explains shock. The fundamental change is a lowering of the difference of potential in individual cells and a lowering of the relative potential of different body structures. The cause of the lowering of potential is sought in a failure of oxidation which is truly the primary cause of shock. He says, " Cells have the power of oxidation only as long as there is a difference of potential between the nucleus and the cytoplasm, and a difference of potential is maintained only as long as there is oxidation." The necessity of oxygen and water for efficient oxidation is emphasized, oxygen being necessary to active oxidation, and water being important as a bearer of oxygen to the tissues, of acid away from the tissues, and for the establishment of a colloidal system. He would therefore define shock as the ultimate result of exhaustion, while exhaustion results from a diminution of the difference in potential between the poles of the organism. This diminution is largely due to a decrease in potential of the brain, which is caused by a decrease in potential between its constituent cells. On the basis of this explanation, he has devised the following methods for clinical avoidance of shock: (1) An abundant supply of oxygen must be delivered to the

cells; (2) an abundance of fresh water must be afforded the tissues; (3) local and general temperature must be maintained near normal; (4) rest and sleep must be obtained; (5) permeability of the selective semipermeable membrane must be maintained within normal range; and (6) physical structure of the cell must not be interfered with by the indirect effects of trauma at operation, or by the anæsthetic.

SPASTIC PARAPLEGIA

The function of the sympathetic fibres, first shown to be present in striated muscle by Perroncito and Boeke, has been the subject of an experimental investigation by Royle, who reviews the conflicting and often contradictory conclusions of previous workers in this field. Goats were used in his animal experiments. He removed the sympathetic abdominal chain in three groups: (1) Animals not otherwise operated on; (2) animals with complete transverse lesions of the spinal cord; and (3) animals whose brain stem had been sectioned at the level of the mesencephalon, producing a condition known as decerebrate rigidity; and in every instance examination after operation showed " that there was a definite change in the lower limb on site of excision when compared with the normal limb of the opposite side." The author describes that change as a depression in reflex activity, and a disturbance of the mechanism for the maintenance of the posture of the limb. On the basis of this experimental demonstration, he has operated on two patients with spastic paraplegia. In the first, in whom spasticity was most marked in the leg, he divided the white ramus from the second lumbar nerve, and the gray rami to the second, third, fourth, and fifth lumbar and to the sacral nerves, which were avulsed through an incision along the outer border of the sacrospinalis with a prolongation forward along the iliac crest. Owing to the depth of the muscles at this point, the technical side of the operation was rather difficult, but its post-operative result was a marked alleviation of the spasticity, so that the patient could move his leg more freely and with much greater control. The leg also showed diminished amplitude of reflex movements, diminished rigidity, increased warmth to the hand but not by thermometer, no œdema, but capillary dilatation. In the second case the rigidity was most marked in the forearm, so the gray rami to the cervical plexus were

avulsed on one side, with the same happy result. From his experimental work on animals, and from his experience with the operation in man, Royle concludes that the function of the sympathetic involuntary muscle is the maintenance of plastic tone. Hunter briefly reviews the physiologic basis of the work, and links up the function demonstrated by Royle with the functions of the sympathetic nerves in other areas of the body. From this study he concludes that the sympathetic fibres generally exercise an inhibitory function over the tissues they supply.

PURPURA HEMORRHAGICA

Kaznelson first noticed the association of an enlarged spleen with the clinical condition which we know as purpura hemorrhagica, in which the blood-platelets are diminished, the coagulation time of the blood is normal, the bleeding time prolonged, the capillary resistance diminished, and the clot does not show retraction. On the basis of this increase in size of the spleen being the cause of the diminution in platelets, he advised splenectomy, which resulted in the apparent cure of the disease. This operation has now been performed on a number of patients with this disease, and post-operative study of them shows: (1) An increase in the number of blood-platelets even as high as a million; (2) the immediate cessation of the hemorrhagic tendency, although this tendency sometimes recurs with lessened severity; (3) the late return, in most cases, of the number of blood-platelets to their pre-operative level; (4) a marked increase of the erythrocytes and hemoglobin consequent on the cessation of the repeated hemorrhages; and (5) the apparent cure of the condition. It has also been shown that two important properties of the blood-platelets have been increased, namely, that which induces clot retraction, and that of agglutination to start thrombi. It is, therefore, concluded that one of the functions of the spleen is to govern these properties.

A review of these post-operative findings shows that, although splenectomy is apparently curative, yet Kaznelson's reason for its suggestion no longer affords a satisfactory explanation of the disease, as there must be other tissues which act destructively on the blood-platelets. Brill and Rosenthal suggest that the reticule-endothelial tissues may be the seat of their destruction.

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CERTAIN AFFECTIONS OF THE SHOULDER AND THEIR MANAGEMENT

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IT IS a familiar experience that troublesome and often lingering pain and limitation of motion in the shoulder may develop, suddenly or gradually, without known antecedent injury or after a trauma— even a slight and indirect trauma.

Such shoulders are usually both " stiff and painful," but since, especially in the subacute and chronic cases, either the pain or the loss of function may much preponderate or exist alone I have preferred as a descriptive the more general term *shoulder disability*.[1, 2]

The pain, especially in acute cases, may be fairly constant. Usually it is intermittent, sometimes spontaneous, sometimes only on motion or attempted motion. Quite often it is very severe at night, interfering with sleep, or relieved only by putting the arm in a certain position. Sometimes, even in long-standing cases, the pain is intense; sometimes it is only a nagging sensation as of a " kink in the muscle."

The pain is perhaps most commonly referred to the outer or the anterior aspect of the arm, but often, although sometimes vaguely, to the shoulder itself—occasionally to the point of the shoulder. In some cases it radiates into the neck, the forearm or even the hand; and it is then that the condition may be mistaken for brachial neuritis.

The most striking feature of the stiffness is limitation of abduction. The patient may be able to raise his arm only 20° or 45° or 90°, and passive abduction will usually be but little more; or he may be able to abduct fully, but awkwardly and with more or less pain. Sometimes, in the more chronic cases, the limitation of motion is due to mechanical obstruction; but usually it is the result of spasm or is caused by pain or the fear of pain. As a rule, the arm can be raised higher when it is brought somewhat forward; testing the degree of abduction—both in diagnostic examination and in the course of treat-

ment—should be by raising the arm only in the frontal plane of the body, as along a wall with the patient's back against it.

Rotation, especially internal, is also usually affected. The patient may not be able to reach his arm behind his back (internal rotation), or to bring his elevated forearm back towards the occiput (external rotation).

Swinging the arm forward and backward is usually fairly free in most types of shoulder disability.

The above is a very brief description of shoulder disability in general. Of some of its varieties more definite signs and symptoms will be considered.

A pathological basis for stiff and painful shoulder was provided by Duplay [3] in his description of " periarthritis of the shoulder "— a condition which he was able to demonstrate at autopsy. The term *periarthritis* is an admirable one insofar as it indicates that the cause of a shoulder disability lies in the structures surrounding the joint and it is, too, useful in suggesting participation of various periarthric tissues in the process. Since, however, we are to-day usually able to determine more precisely the lesion that is present in any given case of shoulder disability it is better to reserve the more general diagnosis *periarthritis* for those cases in which such sharper determination can not be made.

To differentiate the various forms of shoulder disability it is desirable to conduct the *physical examination* systematically and in a good light. With both shoulders and arms and at least the upper chest exposed, and the patient seated, preferably on a revolving stool, observations are made in the following order, *comparing the two sides:*

Attitude, and contour of the shoulders. Note any atrophy.

Active motion: (1) Abduction. Note with examining fingers when the scapula begins to move. (2) External rotation. (3) Internal rotation (carrying the arm behind the lower back). (4) Forward elevation (" flexion ") of the arm. (5) Backward elevation (" extension ").

Passive motion (comparing each with the degree of active motion): (1) Abduction. (2) External rotation. (3) Internal rotation. (4) Circumduction. (5) Flexion. (6) Extension. Here again, especially, control the scapular movements with the hand and note

how much motion is in the shoulder-joint itself. *If the scapula moves with the outset of every arm movement (scapulo-humeral fixation) the lesion is not, or is not merely, a periarthritis, but is in the joint (arthritis, ankylosis).*

Observe the color of the hands; test for sensory disturbances and for nerve tenderness; palpate the root of the neck for a cervical rib.

Examine the deltoid region, the supraspinous and infraspinous scapular regions, and the neck for points of tenderness.

Study X-ray pictures of the shoulder girdles (taken with the arms in two or more positions, dependent and abducted, including external rotation to show the greater tuberosity of the humerus in profile), and, in doubtful cases, also films of the neck.

SUBDELTOID (SUBACROMIAL) BURSITIS

This affection is, in my experience, the most common cause of shoulder disability.

Anatomy.—This bursa is one of the largest in the body. Above, it is adherent to the under surface of the acromion process and the coraco-acromial ligament, wherefrom it is reflected onto the joint capsule. Below, it is adherent to the inner surface of the deltoid muscle, extending fully one and a half inches distal to the greater tuberosity. Anteriorly and posteriorly, it encircles almost one-half the circumference of the humerus, and is attached by its under surface to the bone, the joint capsule, the biceps sheath and the tendons of the supraspinatus, infraspinatus, teres minor and subscapularis. It does not communicate with the joint. The sac is sometimes described as consisting of two portions, subdeltoid and subacromial, which communicate. Indeed, these are sometimes referred to as separate bursæ. Thus, curiously, in "Gray's Anatomy," edited by Spitzka, 1913, we read on page 303, "the subdeltoid or subacromial bursa is placed between the under surface of the deltoid muscle and the outer surface of the capsule," and on page 462, " . . . the subdeltoid bursa often communicates with the subacromial bursa . . ." My own dissections have not shown two sacs. Nor, clinically, is it necessary to regard the bursa as bilocular. It is the central portion, over the greater tuberosity, that is chiefly involved in subdeltoid bursitis.

Pathology.—In the bursa itself the common lesion is adhesions between its two walls. These adhesions may be moderately long, or

short and dense, gluing the two surfaces together over a limited area. Beyond the area of adhesions, which is generally in the region of the greater tuberosity, the surfaces are usually free. Here and there the bursal wall is sometimes thickened, but usually not much so. Villous thickenings and papillary outgrowths, as described by Codman,[4] are occasionally formed, however. Sometimes there is a small amount of serum locked in the subacromial portion of the bursa by the adhesions below it. Probably there is always a serous effusion at the outset, but it usually soon disappears.

Associated with the bursitis itself there is probably always, at least at the outset, an injury to the underlying supraspinatus tendon (or, occasionally, the infraspinatus). This consists of a bruising or actual tear of the tendon,[5, 6] with slight or more extensive hemorrhagic infiltration. As a result, apparently, of necrosis of tendon tissue,[7] there often occurs a deposit of lime and other mineral salts, as seen röntgenographically. This deposit takes place, not slowly, but very speedily after the injury. In many cases it is absorbed in a few months; in others it persists for years, long after all symptoms have ceased. Indeed, it is not very rare to find, röntgenographically, a deposit also in the opposite and presumedly unaffected shoulder.

This lime deposit is, then, not in the bursa,* nor in its walls. It lies beneath the bursa,[4, 5, 6, 8] either wholly within or upon, or partly within and partly upon, the supraspinatus tendon. Occasionally the deposit is in the infraspinatus tendon. Sometimes it will be found scattered about on the periosteum in the neighborhood of the greater tuberosity. Irrespective of the severity of the symptoms, the

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* In previous publications [5,6] I have explained why, even at operations, surgeons have thought the deposit was in the bursa, or failing to open the supraspinatus tendon, have not found it at all, or, when the deposit was fluid, thought they evacuated pus from the bursa. If the two bursal walls, adherent over the deposit, are divided at a single incision, the surgeon, believing he has cut only through the outer wall or roof, will expose the lime mass, unless it is concealed in the tendon; on removing this mass he will encounter the broad supraspinatus tendon, which he believes to be the inner wall of the bursa. If, however, the operator will lift up the outer wall with tissue forceps and incise it carefully, and then divide the adhesions between it and the bursal floor, he will find that he can explore the interior of the sac without encountering the deposit. The latter will not be exposed until he has then separately cut through the inner wall or floor of the bursa, and not even then if, as is very common, the deposits are quite within the tendon.

Fig. 1.
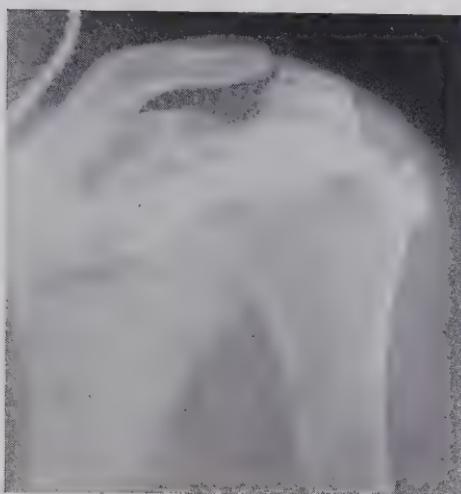
Subdeltoid bursitis.   Lime deposit at supraspinatus insertion.

Fig. 2.

Subdeltoid bursitis, with multiple lime deposits.

FIG. 3.

Subdeltoid bursitis.   Two deposits, one near, and one remote from, the greater tuberosity.

FIG. 4.
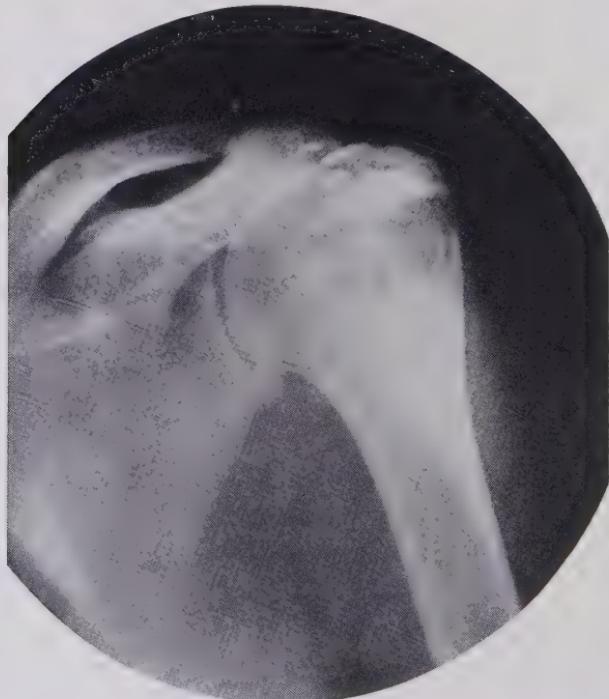
Subdeltoid bursitis.   Very large, dry, cap-like deposit, only partly in the tendon.

deposit may be very small or large, dry and gritty or semi-fluid, single or multiple, near the insertion of the tendon or at a considerable distance from the tuberosity (Figs. 1 to 4).

Etiology.—It is more or less generally assumed, and it is sometimes asserted,[9] that subdeltoid bursitis is infectious or toxic, originating from some focal infection. However attractive such a theory may be, it has very scant clinical and no laboratory facts to support it.[6]

The pathology of the disease, just described, gives indication of what I believe to be its primary cause—trauma. Admittedly, a history of trauma is very often not obtainable. But it must be borne in mind that in normally abducting the arm the bursa and supraspinatus tendon are compressed between the acromion process and the greater humeral tuberosity; and a more violent compression takes place in a sudden, especially if unguarded, hyperabduction—as in beating a rug or from a lurch of a car in which one is " strap-hanging." The history of such an indirect violence in hyperabduction just preceding the symptoms is sometimes related. Sometimes, but less often, there is given by the patient the story of a direct violence, especially by a fall on the outstretched arm.

There is another etiologic factor concerning, at any rate, the often associated subbursal deposit of lime and other salts. This is some undetermined metabolic predisposition: Subdeltoid bursitis is an affection of adult years; it occurs equally in males and in females and in many walks of life; not rarely it is encountered first in one shoulder, then in the other; in some persons the deposit, or deposits, undergo absorption, in others they persist; although a common affection, many persons using their arm in the same way, and subjected to the same influences, never develop it; it occurs among the muscular and athletic as well as the sedentary and asthenic. Curiously, among thousands of soldiers in Base Hospital No. 3, A. E. F., I did not see a single instance of the affection.

Symptoms.—These are but two: Pain and disability in shoulder movements.

Pain is present in almost all cases. It is usually referred to the upper arm, anteriorly or externally, from the level of the deltoid insertion toward or to the elbow. Often, but by no means always, it

is referred also to the shoulder, usually its outer aspect. Sometimes it radiates into the forearm, the hand, the fingers or the neck. The pain may be fairly constant, or intermittent, or only on motion. Often it is worse at night.

Disability of movement may be absent, especially in chronic cases; but in the early stage abduction, at least, is inhibited * or painful. This movement and internal rotation are chiefly affected, but in varying degrees. The patient may be able to raise his arm only a little, or he may be unable to brush his hair. The interference with internal rotation may be great or moderate; the patient may be unable to put his hand in his trousers pocket, or to reach behind his back, or to raise his hand on his back to the opposite scapula. External rotation is usually little affected, but sometimes is much inhibited. The arm can be swung backward and forward. There is no ankylosis.

Physical Signs.—In the early stage there may be slight swelling due to serous effusion. In most cases, when the patient is first seen there is no swelling. On the contrary, there is often a flattening, due to atrophy of the deltoid, and sometimes also of the supraspinatus and infraspinatus muscles.

There is no constant or pathognomonic point of tenderness. Pressure on the bursa externally, below the tip of the acromion process, is sometimes painful, but it is usually painless. The most nearly constant tenderness is *anteriorly,* over the tuberosity. (When the arm hangs by the side the external condyle of the humerus and the greater tuberosity face forward.) When this point is very tender (comparison should be made with the opposite shoulder) it is fairly diagnostic in association with the symptoms. Sometimes the only or greatest tenderness is posteriorly, over the line of the infraspinatus or supraspinatus. Dawbarn's sign—disappearance of point tenderness when the bursa is carried under the acromion by abduction—is only occasionally positive. Pain referred to the outer deltoid region on gently pressing the circumflex nerve against the inner aspect of the humerus [1] is occasionally elicited. (Filaments of this nerve are in contact with the bursa.)

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* Adhesions in the bursa do not, by themselves, prevent abduction. In a case operated upon for persistent pain without limitation of motion I found the bursal walls agglutinated. Adhesions probably persist after treatment, and return after operation.

Röntgenography is important. If it shows nothing it does not exclude subdeltoid bursitis; indeed, this supports the clinical signs insofar as it demonstrates no other lesion. If the shadow of a lime deposit is seen, however small, the diagnosis is fairly established. Finally, the röntgenogram may show some unsuspected lesion, *e.g.,* syphilis or tuberculosis of the head of the humerus, or a small fracture of its tuberosity. It is desirable to X-ray the shoulder with the arm in different positions for, in a single film, the shadow of a deposit may be lost to view against that of the bone.[12]

Clinical Forms.—The pathology of the affection being essentially the same in all grades, irrespective of the amount of stiffness or of pain, the classification by clinical forms which I suggested several years ago [6] seems to me the most satisfactory; and subsequent experiences have given me no reason to modify it. These forms and grades which, however, are not to be sharply separated, are: Acute, hyperacute, chronic, chronic with exacerbations.*

In acute cases, pain and stiffness develop rapidly and reach a maximum in about three days. The pain is quite severe and constant, and subsides little or not at all at night. The arm can be only slightly abducted without great pain. There is spasm of the shoulder muscles, increased by attempted abduction or internal rotation, active or passive.

The term " hyperacute " is used to indicate not so much the rapid development of symptoms as their severity. The pain is very great. The patient hugs his arm to his chest, and the slightest attempt to raise it induces severe spasm. There is a rapid development of atrophy of the deltoid and the spinati. Radiation of the pain into the fingers, with this atrophy, may deceive one into the diagnosis of brachial neuritis. Indeed, the early appearance of atrophy of these three muscles suggests that there may be some associated localized neuritis, especially of the circumflex; disuse for a short period seems not quite sufficient to explain it. There is, however, no suggestion of an injury to the upper cord of the brachial plexus.

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* Two infectious forms of subdeltoid bursitis do rarely occur: The purulent, of which I have seen but four cases, all metastatic from suppuration elsewhere in the body; and the tuberculous, first described by Bilhaut,[10] of which I have seen only one. Sarcoma of this bursa also occurs, very rarely.

In both the acute and the hyperacute forms, tenderness over the tuberosity anteriorly is exquisite.

Acute subdeltoid bursitis may subside completely. More often it passes into the chronic form.

Chronic subdeltoid bursitis begins in the acute form, or is of the same severity throughout. The pain is often annoying rather than unendurable. It may be quite intermittent, varying in severity. Often it is present only on certain motions (as in putting on a coat, or attempting to comb the hair). Abduction may be limited to 45°, 90°, 130°; internal rotation may be much or little retarded. Passive movements are usually a little freer. External rotation is sometimes limited. In many cases the movements are perfect, but usually are then more or less painful. Tenderness over the tuberosity anteriorly is usually present and often great. There may or may not be atrophy of deltoid and spinati.

This chronic form persists for months or years. Usually it subsides in time, and the lime deposit, if any, may gradually disappear completely.

The " chronic form with exacerbations " is of those cases, lasting for years, in which there is often a recession of symptoms, more or less complete, for varying periods, but in which every few weeks or few months there is an exacerbation in which the symptoms approach those of the acute or even the hyperacute form.

Treatment.—The tendency in most cases of subdeltoid bursitis is to recovery, however slow, under various forms of treatment—or in spite of them. In acute cases Wolf [9] regularly employs wet dressings and very light massage. In the chronic types he, like most physiotherapists probably, applies diathermy, baking, massage. It has been my observation that in many cases these measures have failed to relieve, and have even appeared to aggravate the symptoms. Forcible abduction does not appeal to me.

In the management of a large number of cases of subdeltoid bursitis it has been my experience that the treatment that most quickly relieves the symptoms and restores the patient to activity is by a simple method of automatic abduction [11] (followed by Indian club exercises), described below.

This treatment is equally applicable to acute, hyperacute, and

chronic cases. The abduction is of little or no value in chronic cases that have no loss of motion—although the club exercises are beneficial. These cases, in which pain is the only symptom, seem to respond least satisfactorily to therapy. Fortunately, however, they usually recover spontaneously. In all the clinical forms and in all stages of treatment of this affection it should be insisted that the patient wear at least a short undershirt sleeve and that he protect the shoulder from exposure to draughts as, for example, in motoring.

Most cases of subdeltoid bursitis recover under this (or other) conservative treatment. There is, however, a small percentage, in which operation is indicated. These are: (1) Those in which a fair trial of the abduction method in bed fails to relieve pain and spasm or to restore function, and (2) the chronic form with repeated exacerbations.

Many authors still recommend in operative treatment " excision of the bursa." A moment's consideration of the extent and relations of this structure is enough to convince one that what they do is merely excise the affected, central portion of the bursa.[8] If any lime deposit and tendon lesion are also dealt with, and after-treatment is provided for, such an " excision " will no doubt effect a cure. It seems to me, however, that a preferable procedure is the anatomic operation I have elsewhere [2,5] described and illustrated.*

There is a small subcutaneous bursa over the acromion and there are various other bursæ among the muscles about the shoulder, e.g., under the supraspinatus, under the subscapularis and communicating

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* The operation consists in: Splitting the deltoid; raising the outer wall of the bursa from the inner and incising it; dividing all adhesions in the bursa; excising villous or papillary thickenings, if any; incising and retracting the floor of the bursa; removing the deposit, if extratendinous, and suturing any tear in the supraspinatus tendon; or incising the tendon wherever indicated by the röntgenogram and excising the deposits with surrounding tendon fibres, and reuniting the tendon with chromicized catgut (if the defect is not too large); suturing the floor of the bursa with a fine running catgut stitch; anointing the interior of the bursa with a very thin layer of vaseline; suturing the outer wall of the bursa; suturing in layers, without drainage, the deltoid muscle, the deltoid fascia and the skin; abducting the arm in plaster-of-Paris for about a week.

The vaseline may not be important. The reconstruction of the bursal walls is not essential, nor always possible, but it aims at an anatomic operation. The abducted position is also not essential, but it is important, for it shortens the after-treatment, which consists in Indian club exercises and other devices to restore internal rotation and full abduction.

with the joint, under the tendons of the pectoralis major, the latissimus dorsi and teres major, and subcoracoid. Excepting the last-named, inflammation of one of these small bursæ does not occur as an isolated, recognizable lesion. No doubt one or more of these bursæ may be involved, however, as part of a " periarthritis."

SUBCORACOID BURSITIS

This is not a very common affection. Where the bursa is situated below and to the outer side of the coracoid process, partly beneath the coraco-brachialis, there is distinct tenderness, but the same area is often sensitive in brachial neuritis. There is often pain on abduction, or inability to hold the arm up when abducted. The most characteristic pain and disability are in drawing the arm forward as in pulling on a coat-sleeve. Forcibly pulling down on the arm causes pain in the shoulder.

The condition subsides in a few weeks, and supporting the arm in a sling is the most important part of the treatment. Aspirin and codeine are helpful.

MUSCLE AND TENDON INJURIES

Injuries to the *supraspinatus* (and, sometimes, the *infraspinatus*) tendon have been considered above in the description of subdeltoid bursitis. The two lesions go together: The bursitis probably does not exist without some involvement, at the outset at any rate, of the underlying tendon; and injury to the tendon is probably always associated with inflammation of the overlying bursa. It is, however, worth separate mention that, as pointed out by Codman,[13] complete rupture of the supraspinatus tendon with tear of the bursal floor may occur from the same type of internal violence. The patient feels something snap, and the arm falls limp; he has severe pain and is wholly unable to abduct his arm. Such a tear requires suturing. The tendon may be exposed as in operating for bursitis, by splitting deltoid and bursa with an incision extending down from the tip of the acromion. Jones,[14] however, advises the more elaborate approach which he uses for fastening a broken greater tuberosity (*vide infra*). After operation the arm should at once be abducted.

Various efforts have been made to determine other individual muscles or tendons that, by injury (strain), may be concerned as the

cause of a shoulder disability. This has been by eliciting, in combination, tenderness localized to the muscle attachment and pain when that muscle is thrown into action. Brown [15] thus describes tear of the tendons of insertion of the *teres major* and *latissimus dorsi* (together) produced by contracting " with great violence in order to prevent sudden and unexpected abduction." Lovett [16, 17] similarly notes that " pain in internal rotation combined with local tenderness in the *pectoralis major* would establish injury of that muscle " and " if local tenderness to palpation is not present in the pectoralis major muscle, and internal rotation is painful it may be assumed that the injury is to the *subscapularis* tendon or the anterior capsule of the joint or to both." These four muscles are internal rotators and adductors. Therefore, if it can be clearly established that injury to one of them is the essential cause of a shoulder disability, its postural treatment, in the acute stage, should be in the sling position (adduction). This should be supplemented by voluntary movements within the limit of pain; and soon thereafter it should be followed by massage, and by graduated abduction to prevent muscle shortening.

In 150 successive shoulder injuries observed at the Cambria Steel Company hospital Replogle [18] found that about 25 per cent. were sprains of various muscles or muscle groups; and, excluding severe contusions, the most frequently encountered traumatic lesion of the shoulder was what he described as *sprain of the rhomboideus minor* muscle at its insertion in the scapula. It is produced by those strenuous movements that raise the lateral angle of the scapula and stretch the interscapular muscles, especially the rhomboideus minor. At the time there is a sudden, stabbing pain just median to the base of the spine of the scapula. This lasts about twenty minutes, but the patient resumes his work. That night there is aching between the shoulderblades and the next day there is pain on using the arm. There is then a point of localized tenderness just internal to the base of the spine of the scapula; and pain, referred to that point, appears when the arm is abducted to 90°, and increases as the arm is further raised. Replogle's treatment is devised to relax the overstretched muscle: The shoulders are thrown back and thus held with criss-cross adhesive straps, with a small pad over the point of tenderness; and the arm is placed in a sling.

Biceps tendinitis is an acute condition that is usually attributed to overstrain. The pain is referred to the region of the bicipital groove where there may be detected slight swelling and, on biceps movement, crepitation. This pain should be elicited when the supinated forearm is flexed against resistance. The extremity should be kept at rest in a sling.

Lovett [16, 17] refers to *deltoid* strain but he does not clearly say that such an injury occurs. I have seen no instance of it. Injury to the deltoid by external violence is easily recognizable by the localized pain, swelling, tenderness and ecchymosis, and pain on attempted active abduction. It should be treated by supporting the arm with sling and pillow in abduction (*vide infra*) and, after a few days, in a well-fitted ambulatory sling. Early massage, to encourage absorption of the blood and to prevent atrophy, is important.

SPRAIN

Sprain of the shoulder may occur as of any other joint in the extremities but, for obvious anatomical reasons, it is less easily recognizable as such than, for example, sprain of knee or ankle. The capsule of the shoulder-joint is quite lax and the ligaments do not support the arm; this is accomplished by some of the surrounding muscles. It is reasonable to assume, therefore, that in sprain of the shoulder there is more or less participation of these juxta-articular structures—a traumatic periarthritis. Thomas [19] described small tears of the axillary portion of the capsule as occurring in sprains and believed that the contracture resulting from the periarthritis thus produced is *the* common lesion in stiff and painful shoulder.

Sprain of the shoulder produces severe spontaneous pain, increased by passive or attempted active movement in any direction, and " some sense of deep swelling," as described by Lovett,[16] who also states that tenderness is usually acute " below and outside of the coracoid where the synovial membrane is most accessible."

Shoulder sprain should be treated from the very outset by graduated abduction in recumbency, without fixation. An ice-bag may give much relief in the first hours, and sedatives may also be required. Gentle massage should be begun very early and movements, within the limit of pain, after a few days. Later, radiant heat is often helpful to encourage absorption of exudate and to relax muscle strain; and

carefully controlled exercises should be employed to restore full active movement in each direction. " Crawling up the wall " with the fingers, with the arm in the frontal plane, is one of the devices to improve abduction in recovery from this as from other types of shoulder disability. Chronic " synovitis " may develop if intelligent treatment is not pursued.

The physician should not commit himself to the diagnosis of sprain of the shoulder after a fall, especially a fall upon the hand, for he may be embarrassed a couple of weeks later to find that he has to deal, instead, with a more serious condition—*subacute traumatic arthritis.* Jones,[20] especially, has called attention to this as developing two or three weeks after a fall on the hand such as produces a Colles's fracture. He has aptly described it also as " stubbing of the shoulder " and attributes it to crushing or bruising of articular cartilage, the pain and stiffness appearing when vascularization is active. It should be treated by resting the joint in abduction for " at least three weeks." There is a tendency in this condition to the development of adhesions that lock the joint. If this occurs in spite of abduction or from neglect of it, breaking the adhesions under narcosis will probably be required. This should never be performed until all inflammatory symptoms have subsided and then must be conducted with great care lest damage be done to blood-vessels, nerves or other soft parts or to the bones themselves. The technic and precautions to be observed in brisement of the shoulder are admirably set down by Jones.[14, 17, 20] It should be followed by holding the arm in abduction of at least 90°, but preferably more; the method described below has the advantages of avoiding fixation and of steadily increasing the abduction arc. The brisement may have to be repeated. Active movements should be begun soon after reaction from the manipulation has subsided.

FRACTURE OF THE GREATER TUBEROSITY OF THE HUMERUS

When of considerable extent and due to external violence (as a fall), this fracture may be recognized by the local pain, tenderness, swelling, and ecchymosis. But it may also be produced by the same type of mild or internal violence as causes subdeltoid bursitis, and can then be differentiated only by the röntgenogram; and here, too,

the simulation is close, for to the inexperienced the shadow of the usually small bone fragment may much resemble that of a calcareous deposit. That the signs and symptoms of subdeltoid bursitis are the same as those of fracture of the tuberosity is not surprising for the pathological anatomy is much the same in both: In one there is a tear of the supraspinatus near its insertion, in the other there is a tear through the bone at this insertion; in both there is an inflammatory reaction in, or possibly even a laceration of the floor of, the immediately overlying bursa.

All too commonly fracture of the tuberosity is treated by bandaging the arm to the chest—a vicious practice that invariably results in a stiffness of the shoulder that takes many weeks to overcome. The essential treatment is abduction—to relax the supraspinatus and the bursa, to approximate the fracture surfaces, and to obviate shortening of the adductor-rotators. If the fragment is large and shows a tendency to displacement when the arm is dependent the latter should be fixed in abduction of 90°–130°, and external rotation, in a plaster cast or on a splint. Jones [14] describes a method of holding the arm in outward rotation and abduction for tuberosity fracture " by putting a clove hitch around the wrist and passing the bandage behind the head under the opposite axilla, and by a firm spica bandage over the injured shoulder."

The tuberosity fracture produced by internal violence is, however, usually a small fragment (from the superior facet) that shows little tendency to displacement, for it is attached to the supraspinatus tendon the lateral portions of which are still attached to the humerus. For these, therefore, fixation in abduction is an unnecessary hardship. The simpler plan of treatment by the author's abduction method, described below, has proven more satisfactory.[21] As compared with fixation in abduction, it has the great advantage, among others, that it can be applied for an hour or two night and morning by the patient himself, who may go about his business during the day with his arm supported in a sling. Sometimes even a gross fracture of the tuberosity shows no tendency to displacement and may then also be treated by this method. Such was the case illustrated in Fig. 5, a complete fracture of the tuberosity through its base, produced by a fall. This patient, treated by the author's method, lost but two days from his

business and, with the help of Indian club exercises, recovered with a painless, fully functioning shoulder.

In those few cases of tuberosity fracture in which there is much displacement which cannot be overcome by abduction, the fragment should be fastened in place by operation. The field may be exposed by the same approach as described above for the subdeltoid bursa and for the supraspinatus tendon. Jones,[17] however, makes a more extensive exposure: The incision, across the shoulder, is carried directly through the acromioclavicular articulation; the acromion process is sawn through at its root; and this process and the deltoid muscle are turned downward.

Gross fractures of the upper end of the humerus, or of the *scapula,* like diseases of the joint itself, are outside the purview of this presentation. Occasionally, however, in a fracture through the head of the humerus the fragment is in fairly good position with no tendency to displacement. In such a case the author's abduction method may be a desirable substitute for fixation in abduction, especially in an old subject.

Lesser fractures (*e.g.,* chipping of the glenoid rim, infraction of the acromion) may be found to be the result of a trauma causing shoulder disability. They should be treated by intermittent abduction, to obviate the development of prolonged stiffness.

SUBLUXATION

Although traumatic subluxation of the shoulder was described by Astley Cooper, Malgaigne and other early writers, many, at least, of these cases were true dislocations or were complicated by other conditions (fracture, rupture of the long head of the biceps,* or some arthropathy); and the occurrence of an uncomplicated, incomplete, traumatic shoulder dislocation was denied by Hamilton, Stimson, and others. In the last edition of his work, however, Stimson [23] accepts as instances a case reported by Russ [24] and three cases reported by

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* *Dislocation of the long head of the biceps,* as an isolated lesion, is probably rare. The tendon is palpably out of its groove, into which it can be manipulated. If it does not remain in place, suture of its sheath, or some other anchoring operation, will be necessary. *Rupture of the long head of the biceps* is also rare. It is recognizable by pain, weakened biceps function and, sometimes, appearance of a lump when the biceps is contracted. Unless due to disease, the tear should be sutured (Keen [20]).

me.[25] In Russ's case the injury was produced by a fall, in my cases probably by mild violence. It is marked by slight prominence of the head of the humerus in front, a corresponding depression behind, and slight flattening of the deltoid—all much less than in full dislocation. It produces pain in the shoulder, radiating down the arm, and inability to abduct; rotation, however, may be but little inhibited. Röntgenography showed nothing abnormal (stereoscopic pictures not made). In my three cases the deformity disappeared (in two with a distinct snap) on abducting the arm to the horizontal, and reappeared when the arm was lowered; continued abduction in bed for ten to fourteen days effected cures.

SPONTANEOUSLY REDUCED DISLOCATION

Undoubtedly in some of the cases of shoulder disability following trauma there has been an unrecognized spontaneously reduced dislocation.[1, 19] In a quite recent case this may demonstrate itself during examination by recurrence of the dislocation if the arm is raised.

DISABILITY AFTER DISLOCATION

Following dislocation of, or fracture near, the shoulder there is always a pronounced and lingering disability if there has been prolonged immobilization in adduction. After reduction of a dislocation (other than habitual), whether spontaneously or by manipulation, the arm must be kept in adduction long enough to allow repair of the capsule. It is, indeed, advisable to bandage the arm to the chest for a week or ten days. This may then be replaced by a triangular sling which allows a little play of motion in the joint. By the end of the third week slight abduction should be begun, to be very gradually increased until the maximum is reached in about eight weeks. This graduated abduction can be accomplished by the bed sling and pillow method described below, which may be employed intermittently, e.g., for an hour or more night and morning. Active and passive movements (controlled exercises) and massage, gradually instituted after four weeks, are needed to restore full function.

TRAUMATIC PERIOSTITIS

Contusions of the shoulder may produce periostitis over bony prominences, as the acromion and the spine of the scapula. It should be treated during the period of pain by supporting the arm in a sling

with, however, early encouragement of movements. A wet dressing may prove soothing at the outset.

LESIONS IN THE UPPER END OF THE HUMERUS

Other than fracture of the greater tuberosity, affections of the upper end of the humerus do not belong among the causes ordinarily considered in " stiff and painful shoulder." It must be remembered, however, that a *syphilitic process in the humerus* may give signs and symptoms of, for example, an acute subdeltoid bursitis. It is, however, recognizable röntgenographically, as are *tuberculous* and *pyogenic infections* and *neoplasm* of the bone.[26]

IMMOBILIZATION

Finally, a very common cause of " stiff and painful shoulder " is the faulty treatment of an earlier shoulder disability—especially by adduction and prolonged immobilization. The condition will usually respond to graduated abduction, supplemented by massage and active and passive movements. When, however, the stiffness is due to joint adhesions these measures usually have to be preceded by manipulation under narcosis.

ABDUCTION TREATMENT

It will be seen that in the treatment of the various forms of shoulder disability, with few exceptions, abduction is important; and it has been emphasized that failure to institute abduction and mobilization is in itself a cause of prolonging a shoulder disability—from shortening of the adductor-rotators and organization of periarthric exudate. Other writers on this subject also refer to the importance of abduction but to secure it they resort to the employment of an abduction splint.

Where fixation in abduction is desirable (as in certain fracture cases or to secure, in infectious arthritis, ankylosis in optimum position) an abduction splint or plaster cast is indicated. But in the types of shoulder disability here considered fixation is neither necessary nor desirable. For all of these the abduction splint has the following disadvantages:

It does not allow any play of motion in the joint, and thus it encourages muscle atrophy and shortening and organization of periarthric exudate.

It cannot be applied, in acute cases, without pain or without narcosis.

It does not afford continuous, gradual increase of abduction. Each increase requires removal and readjustment by the surgeon.

It does not attain restoration of the full arc of abduction.

It holds the arm in partial internal rotation and does not secure external rotation.

It provides no means of intermitting the abduction when that position becomes uncomfortable or painful.

It is often painful and always very awkward.

Codman himself said that this method, which he applied in subdeltoid bursitis, "was a very arduous one for the surgeon, and caused a great deal of complaint from the patients," and that "the splint, in order to be comfortable, required frequent adjustments . . ."

Throughout this article I have spoken of "intermittent abduction," "graduated abduction," "automatic abduction," "abduction in bed," etc. These references are to a simple method [11] which I devised several years ago to obviate all the disadvantages of a splint, and which has continued to give eminent satisfaction in the management of shoulder disabilities.

In bed, semi-recumbent on an incline made of three, four or five pillows, not too soft, the patient is told to abduct his affected arm, on the pillows, as far as he *comfortably* can. It will usually be noted that, relaxed in recumbency, his abduction is at once considerably more than when he was standing. Beneath the arm, thus comfortably abducted, a loop of surgical gauze or of a folded towel, is passed above the elbow, and fastened to a convenient place on the headpiece of the bed (Fig. 6). A small pillow is placed under the arm as an additional support. When external rotation is impaired the hand will not drop back against the pillows and it may then be desirable to place a pad behind the forearm. If the head of the bed is raised it will increase the tendency for the patient to slide down. As his body little by little slides down in bed his arm travels relatively further and further up, and thus a shoulder that resists forcible efforts at abduction yields steadily to this gradual countertraction, which the patient often does not even feel. It is striking to observe that a person whose shoulder for months has not been abducted, actively or passively, beyond 45°,

Fig. 5.

Gross fracture of the greater tuberosity of the humerus, without displacement, treated
by the author's abduction method.

Fig. 6.

The author's easily regulable method of securing abduction in the treatment of shoulder disability. Note the incline of pillows, the small pillow under the arm, the loop of gauze from the cross-bar of the bed and above the elbow, and elevation of the head of the bed.

Fig. 7.
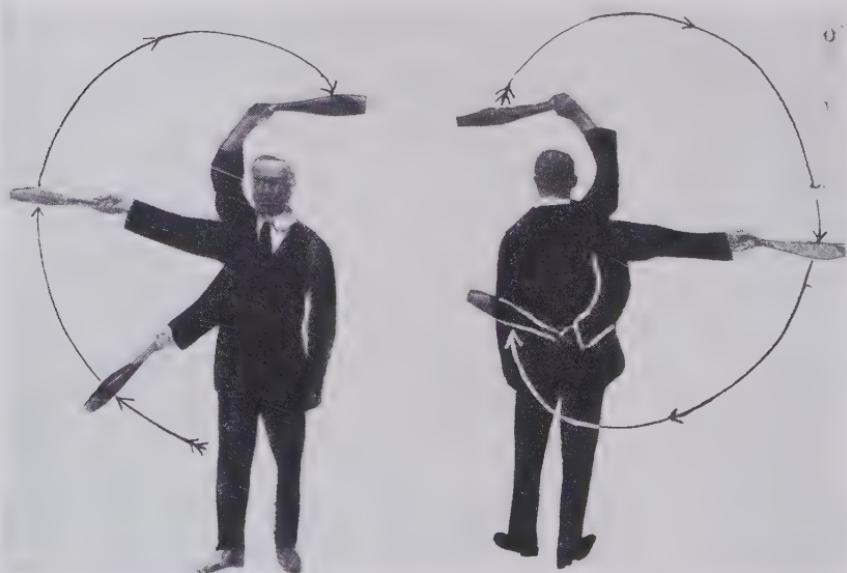
Indian club exercise to increase or maintain abduction and to restore external and internal rotation.

put thus to bed in the afternoon, may be found the next morning with his arm alongside his head!

A hot pad on the shoulder is soothing, and codeine and aspirin are helpful when there is pain. When the abduction position becomes irksome the patient may relieve it by pulling himself up on the pillows or by taking his arm out of the loop. Many patients cannot sleep with the arm thus raised; indeed, it is often desirable (except, for example, when thus treating a subluxation) to intermit the abduction for longer or shorter intervals, for sleep, for meals or for other reasons. In acute cases it is advisable that the treatment should be fairly continuous, but in milder or more chronic cases it may, instead, after a day or two, or from the outset, be employed for only a couple of hours night and morning, thus allowing the patient to attend to his business during the day.

It will be seen that the method lends itself to regulation by the patient himself and needs little attention from the surgeon. As the arm moves up the sling is to be shortened or shifted accordingly. Sometimes it is desirable to loop the sling or an additional sling about the wrist, which will also increase external rotation. In suitable cases, free from spasm, a sling may be passed over the cross-bar and carried down to the opposite hand, the patient amusing himself by pulling upon it from time to time. Other adaptations will suggest themselves, *e.g.*, a back-rest may be substituted for some of the pillows and a couch or Morris chair (though less satisfactory) for the bed.

Full abduction may be thus secured in from one to seven days; it seldom takes longer. Once attained, the treatment should for a while, at least, be continued for a brief period each day; the sling will not then be required, probably, but the patient should recline for an hour or so with his forearm above his head.

At this time internal rotation will still be affected. An Indian club exercise is then invoked to secure its restoration and to maintain abduction. This exercise (Fig. 7) is performed with a single light club (1½ pounds) the patient standing before a mirror. Holding the club by his side, with the arm rotated out, it is *swung* (not lifted) up briskly, but *not violently,* over the head, the forearm then coming down a little behind the head (external rotation). Then the club is carried back through the same arc and up as far as possible behind

the back. With internal rotation unimpaired one should be able with the arm behind the back to put the finger tips over the lower angle of the opposite scapula; and the patient should be encouraged to persist in the Indian club exercise until he can accomplish this.

The mirror is desirable to correct the tendency to swing the arm forward. *The movement is to be carried out in the frontal plane* of the body, *i.e.,* parallel with the wall the patient is directly facing.

It is important, too, that the exercise should be neither violent nor long-continued, and it should be stopped at once if there is much pain. Either pain or fatigue may spell relapse of the shoulder into an irritative and spastic state. Swinging the club up and down two or three times, twice daily, is enough at the outset, and an increase to twelve times twice or thrice daily is a sufficient maximum.

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OVARIAN TUMORS IN CHILDHOOD *

WITH A REPORT OF A LARGE OVARIAN CYST IN A CHILD OF TEN YEARS

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OVARIAN tumors occur not uncommonly in childhood, being rare in infancy, however, but more frequent as puberty approaches. Diseases of the internal genital organs, the uterus, uterine tubes, and ovaries for the most part arise during the period of sexual activity, and the cases occurring later in life are as a rule due to the further development of diseases which have already started in middle life. While this is true in general, a careful search of the literature shows that pelvic affections during childhood are of far more frequent occurrence than is usually supposed. In some instances conditions first observed after puberty are actually due to diseases existing earlier in childhood, but not attracting attention until the organs are called into active use.

Almost all forms of diseases of the tubes and ovaries found in adults have been observed during childhood; certain pathological conditions being relatively more frequent at one period than at another; thus, in children under three years, ovarian tumors have been found principally, and these either dermoids or sarcomata.

Cystic ovaries are frequently observed in infants and have been described by deSinety and others. According to Kissel's investigations these cases of cystic follicles are rare in children after the first year, and they should not be confounded with the adenocystomata, which make up a large proportion of the ovarian tumors of later childhood and adult life.

While ovarian tumors may be found in the earliest years of childhood, they become more frequent in girls approaching puberty. Half of the tumors at this period belong to the cystomata. A few carcinomata have been described in older children, and inflammatory disease and tuberculosis also occur.

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Diagnosis.—The diagnosis of diseases of the tubes and ovaries in children may usually be made without difficulty. The diagnostic signs are the same as those in adults, with the notable exception of the differences in the topographical relations. Owing to the relative smallness of the abdominal cavity, a tumor will begin to encroach upon the vital space in a child when it has reached a size which in the adult would scarcely be noticeable. In this way an ovarian tumor the size of a child's head, lying in the abdomen, stands so high and occupies so much space that it may at first slightly resemble a tumor either of the liver or of the kidney. Owing also to the smallness of the pelvic space and the straightness of the canal, the tumor is extruded earlier into the abdominal cavity than is usual in the adult.

The most complete article on the subject of ovarian tumors in childhood is written by Howard Kelly and appears in "Keating's Cyclopedia of Diseases of Childhood." He collected reports of 126 cases of ovarian tumors in children; 155 were cysts; 47 dermoids and 24 were solid. Of fifty-five cystic operations upon children, four died, a mortality of $7\frac{1}{3}$ per cent. The youngest case reported occurred in an infant four months old; the next ones in point of age were three and four years, respectively.

OVARIAN TUMORS

The ovarian tumors occurring in children may be classified as follows:

Cystic tumors ....{ Adenocystomata. Unilocular cysts. Dermoid cysts.

Solid tumors..............{ Sarcomata. Carcinomata.

Adenocystomata, or multilocular cysts, the classical ovarian tumors, form the most numerous group of ovarian growths occurring in childhood, and are in all respects similar to the ovarian cysts found in adults. Probably the largest cyst observed during childhood is the case successfully operated on by W. W. Keen, of Philadelphia. The patient, fifteen years of age, for two years had noticed an increasing abdominal enlargement, accompanied by pain in the left side. She had been tapped twice, eighty-four pounds of fluid being removed. At the time of operation, the abdomen was greatly distended, measur-

ing forty-nine centimetres in circumference, and the superficial veins were prominent. Extirpation was affected without difficulty, as there were but few adhesions. The patient made a good recovery. The tumor was a multilocular ovarian cyst weighing one hundred and eleven pounds.

DERMOID CYSTS AND TERATOMATA

These tumors are for the most part of medium or small size, rarely attaining large dimensions. They are sometimes monocystic, at other times multilocular, in some instances the dermoid elements are present in only one loculus, while the remaining portion of the tumor is identical with the ordinary adenocystomata.

A strong confirmatory evidence of the origin of dermoids from misplaced embryonic tissue is the frequency with which they are met with in children and the comparatively early period of life at which they are observed in adults. The average age of all the patients operated on at the Johns Hopkins Hospital[1] for the extirpation of dermoid cysts was only twenty-six years. Of the ovarian tumors found in children, one-third, a high percentage, contained dermoid elements. Tumors of this nature are in some instances congenital.

Dermoids are of slow growth, and often do not manifest their presence until adult life, the normal function of the ovary remaining undisturbed. This is readily understood from their histological structure, as the majority of these tumors contain developing and mature follicles, especially numerous in the vicinity of the hilum. Many of them also contain endo-, ecto- and mesoblastic structures. Dandois successfully removed from a child of seven years of age a large tumor weighing 7½ kilograms, which contained cysts filled with colloid or sebaceous matter and hair, and a third of its weight consisted of bone.

SOLID TUMORS

Sarcomata.—The activity of the ovarian stroma in early life suggests an explanation of the relatively frequent occurrence of sarcoma of the ovary in children. Congenital tumors often belong to this group, and frequently their histological elements bear a striking resemblance to embryonic ovarian stroma. In their histologic structure, sarcomata occurring in infancy and childhood comprise several varieties; by far the greatest number, however, consist of small round

Fig. 1.

Patient in erect posture, showing marked pendulous abdomen, due to abdominal tumor.

Fig. 2.

Patient in prone position, showing enlarged abdomen.

Fig. 3.

Tumor removed at operation.

Fig. 4.

Large ovarian tumor, removed from negro child of ten years. (Note size of tumor compared with eighteen-inch ruler.)

cells. A few belong to the spindle-celled variety; one was described as a lymphangioma, another as an endothelioma, and Gage describes his case as a fibrosarcoma. In a few cases (three out of twenty-seven) both ovaries were involved.

Carcinoma.—There are on record six cases of carcinoma of the ovary occurring in children, a large number considering the rarity of carcinomata in general in early life. Carcinoma occurs somewhat later than sarcoma. Redner operated on a child of nine years for an ovarian tumor which proved to be a carcinoma. Extirpation was without difficulty, as there were no adhesions, and the child promptly recovered from the operation. One year later, however, she died from recurrence.

A number of interesting case reports appear in the literature regarding ovarian tumors in childhood. Petersen [2] reported a case of a large ovarian tumor in a girl aged eleven years. The tumor had undergone suppuration and was probably infected from hairpins impacted in the vagina. McGillroy [3] reports a large multilocular ovarian cyst in an infant aged eleven months. Cowie [4] reported a case of malignant multilocular cyst in a girl of eleven years.

REPORT OF CASE

I wish to report a large ovarian tumor in a negro child of ten years. I consider this case worthy of mention, first, because of its large size, and second, because ovarian tumors are not as frequent in the negro race as they are in the white. This case was in a negro child of ten years of age living in Prince George County, Md. She was referred to me on November 1, 1921, by Doctor Sansbury, of Forestville, Md. She was sent to consult her doctor for what her mother considered a large distended abdomen. She gave the following history:

Family history, negative; measles and mumps in childhood, good recovery. Always been in good health, strong and well; no cardiac or respiratory trouble; no genito-urinary trouble; she had nocturia, having to get out of bed two or three times a night to pass urine since she was six years of age; she has never menstruated; has had no vicarious menstruation.

Present Illness.—About one year ago, the patient noticed, and also her mother, a gradual swelling of the abdomen. This swelling persisted since the time of onset and has been progressively growing larger. There were no acute symptoms, associated with the swelling. She has never been confined to bed; has no fever; no pain; no nausea; no vomiting. She has had no œdema of the ankles;

no cough; no discharge from the vagina; no cardiac trouble. She is chronically constipated and feels a sense of fulness and tightness in the abdomen.

On physical examination, I found a moderately developed negro child of ten years; head and neck normal. Blood-pressure, 120–82. The abdomen was large, prominent, projecting forward and somewhat pendulous, especially upon standing. There was definite fluid fluctuation and there was a flat note to percussion. The fluid was apparently encysted. The entire mass could be distinctly felt in the upper abdomen, and there was marked fulness and flatness to percussion. There was no irregularity in outline. (Figs. 1 and 2.)

Vaginal examination: Hymen intact and unruptured. Rectal examination: Uterus was not palpable; nor appendages. Fluctuating mass was felt distinctly on rectal examination. Blood-count: Hemoglobin, 80 per cent.; red blood-corpuscles, 3,000,000; white blood-corpuscles, 6200. Urine: Specific gravity, 1.018. Negative. Coagulation time: 1 minute.

Operation.—November 31, 1921, under nitrous oxide and ether anæsthesia; a median incision was made and upon opening the abdomen, a very large ovarian tumor was found which was slightly adherent to the omentum. The tumor originated from the right side; the tumor was delivered through a large incision and removed in the usual manner. (Figs. 3 and 4.) Patient returned to her room and made an uneventful convalescence. She was discharged on November 20th, and returned to her home, and has been in good health, but to date has not menstruated.

Pathological Report.—Large multilocular cyst weighing 11½ pounds; and measuring 11″ x 10″ x 9″. In one pocket of the cyst was a small quantity of hair showing it was some form of a dermoid.

This case, I thought, was worthy of mention because of its unusual occurrence, the large size of the tumor and the fact that it occurred in a child of ten years of age who had never menstruated, and in the negro race.

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[1] *Johns Hopkins Hospital Report;* Kelly's article in "Keating's Cyclopedia of Children."

[2] PETERSEN, H. J.: 1910–1911, *Proc. Roy. Soc. Med. London, Obstet. and Gyn.,* 259–263.

[3] McGILLROY: *Loncert Lond.,* 1907, 1, 1487.

[4] COWIE, D. M.: *Phys. and Surg.,* Ann Arbor and Detroit, 1913, 35, 200.

THE DANGERS OF TAXIS IN STRANGULATED HERNIA

By LEIGH F. WATSON, M.D.

Chicago, Illinois

THE earliest historical reference to taxis for strangulated hernia is found in the writings of Praxagoras of Cos, about 300 B.C.

As the ancients never operated for strangulated hernia it is probable that taxis is as old as hernia, and was employed by primitive man in remotest antiquity. It is sometimes permissible to try taxis in strangulated hernia when the patient is seen within two or three hours after the onset of symptoms. It is more likely to be successful in infants and children than in adults, and for large hernias more than for small ones, and in inguinal and femoral hernias more than in umbilical hernias. Taxis should never be continued for more than five minutes and only a moderate amount of force should be used, even with the patient under anæsthesia.

There are certain postures that are an aid to taxis. Infants and children can be suspended by their feet, or slung up over the shoulders of an assistant while taxis is employed. A hot bath before this manœuvre is often helpful; this was employed by the ancients, who also suspended the patient by the feet to facilitate reduction.

For adults, the following positions sometimes favor the success of taxis: The knee-elbow, knee-chest, Sims', and Trendelenburg positions with the knee bent.

Taxis is contra-indicated under the following conditions: (1) When the hernia has been down several hours; (2) when the onset is acute and the symptoms are severe; (3) when previous attempts at taxis have failed; (4) when the coverings of the hernia are inflamed or œdematous; (5) when there are symptoms of prostration and shock; (6) when there are signs of ulceration and gangrene.

Taxis is little used at the present time on account of the danger of returning gangrenous intestine to the abdominal cavity, and the chance of reducing the strangulation *en masse*. The directions for taxis are given, because the patient may refuse operation, his condition may not warrant it, and circumstances may be such that imme-

diate operation is impossible. The method of taxis of Cooper has never been improved; he directed that the bladder be emptied and the patient placed in the recumbent position with a pillow under his shoulders and another one under his hips; the thighs are elevated to a right angle with the body and the knees brought close together to relax the internal ring. The surgeon stands at the right side of the patient. With his right hand, he presses on the fundus of the hernia, and at the same time, with the index finger and thumb of the left hand, he gently moves the neck of the sac from side to side to aid reduction. If a part of the tumor can be reduced, the rest generally follows without difficulty.

The hernial contents that come down first lie in the front part of the sac, while those that come down last lie behind. For this reason the viscera in the posterior part of the sac should be reduced first.

The degree of force must be moderate, but continuous. Violent manipulations frequently rupture the intestine. The direction of pressure should be toward the anterior superior spine. Richter advises drawing down the sac to straighten out its neck, while making pressure. If the hernia cannot be reduced in five minutes, it is useless to continue taxis longer. Taxis is aided in infants and children by holding them by their feet, head downward. Inversion of the patient, as a means of reducing hernia, was practised by the ancients, and revived after the Dark Ages by Guy de Chauliac.

Other measures that often aid taxis are: Hot baths, local applications of cold compresses, ice, ether or ethyl chloride spray; in isolated cases hot applications are helpful.

In reducing intestine and omentum, the intestine reduces first, with a gurgling sound. The patient often complains of pain, and children cry from it, especially when the hernia has been down for some time; and it is probably due to peristaltic contractions of the intestine set up by the manipulation of taxis. The omentum and mesentery are ordinarily difficult to reduce, and sometimes they are adherent to the sac, so that complete reduction is impossible. Cases of this type nearly always have a history of an old incompletely reducible hernia.

In case taxis fails, operation should be resorted to immediately, as there is always grave danger that the efforts of taxis may have

ruptured the intestine. If taxis is apparently successful, the patient should be carefully watched for several hours for symptoms of laceration of the intestine, hemorrhage from the blood-vessels of the omentum or mesentery, or reduction of the hernia *en masse*.

The principal dangers of taxis are: (1) Reduction of the hernia *en masse* with a persistence of the symptoms of strangulation; (2) rupture of the intestine; (3) contusion or laceration of the intestinal wall; (4) the reduction of gangrenous intestine into the abdominal cavity; (5) the forcing of infected sac contents into the peritoneal cavity; (6) the danger of ulceration and perforation of reduced intestine developing several hours or days after reduction; (7) the occurrence of intestinal hemorrhage, resulting from too forcible taxis; (8) incomplete reduction—the reduction of only part of the strangulated intestine into the abdominal cavity; (9) rupture of the sac near the neck and the subperitoneal reduction of the hernia; (10) the danger of tearing loose the constriction at the neck of the sac, and reducing it along with the intestine into the abdominal cavity; (11) the danger of failing to relieve the strangulation when the constriction is intrasaccular; (12) torsion of the loop persisting after reduction; (13) intestinal paresis that often follows forcible or repeated taxis; (14) separation of the mesentery; (15) acute volvulus of the intestine; (16) intussusception; and (17) omental torsion and stenosis of the intestine as a late complication.

Immediate operation is the treatment of choice for strangulated hernia. As Stromeyer remarked nearly a century ago, if a case of strangulated hernia is seen in the day time, the patient should be operated on before the sun sets, and if it is seen in the night, he should be operated on before the sun rises.

CLINIC ON ACUTE APPENDICITIS *

By I. S. RAVDIN, M.D.
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It is frequently said that the Surgical Department spends too much time in discussing appendicitis with students. However, when we consider that nearly 50 per cent. of the cases of appendicitis admitted to the surgical wards of this hospital have acute appendicitis associated with a local or diffusing peritonitis, you can readily see why this is necessary. It seems almost impossible that such a state of affairs should exist. In 1886, Fitz advocated early surgical intervention as the treatment for acute lesions of the vermiform appendix and to his powerful writings have been added those of Murphy, McBurney, Ochsner, Deaver, Moynihan and many others.

On Surgical Division B, it has been our practice to operate on all cases of acute appendicitis as soon as the diagnosis has been made. There are certain exceptions which I will mention later. It is for this reason that you rarely see a case of acute appendicitis operated on during clinic hours. These patients are not admitted to suit our convenience, but we make it an invariable rule to operate as soon as possible after the admission of the patient and the confirmation of the diagnosis. We have frequently found it difficult to depend upon a typical textbook picture for diagnosis, for the symptoms vary with the anatomical position of the appendix, the virulence of the infection and the individual patient's reaction to inflammatory changes.

Before operation an attempt is always made to determine the exact position of the appendix and the extent of the inflammation. The pain in appendicitis must be explained on an anatomical and a physiological basis. The abdominal viscera are supplied by the sympathetic nervous system, and disturbed action of this system as the result of lesions of the viscera is the chief cause of the symptoms of visceral disease. In order to understand the reflex symptoms as they relate to appendicitis, it is only necessary to describe the sympathetic

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system proper since the parasympathetic or cerebral autonomic system plays no part. Sympathetic fibres make definite connections with the various spinal segments beginning with the second dorsal and ending in the second lumbar segment. These sympathetic fibres emerging from a spinal segment may end in the ganglion with which the ramus is connected, or they may course upward or downward to another ganglion, or they may pass through the sympathetic trunk to end in a peripheral ganglion. It is through this intricate connection that a single segment may be connected with a number of cells at definite levels, and it is this which accounts for the partial interradiation of sympathetic impulses.

Due to the constant anatomical arrangement of the nerve-supply to the viscera, the reflex expression of irritation remains constant as long as the inflammatory change has not involved the parietal peritoneum. It is very improbable that there are separate pain fibres in the sympathetic nerves since, as Foster, Sherrington and Head have pointed out, they may never be used during the lifetime of the individual. However, there is a very high latent sensibility which may become apparent during processes of inflammation. As Hurtz has pointed out, the only adequate stimulus to true visceral pain is tension. Therefore, under abnormal conditions, afferent impulses from the abdominal viscera are capable of arousing pain, discomfort, and various reflexes of the abdominal wall. Since the sympathetic nerves make a central connection with certain spinal segments, the reflex of the lesion is found in the somatic segment which receives its superficial nerve-supply from the same spinal segment.

Pain is the most constant symptom of appendicitis, but it varies widely in position and severity. It is never an absolute indication of the extent of the disease because of the variability of individual reaction to pain depending upon whether the patient is hypo- or hyper-sensitive. The initial pain in appendicitis is due to distention of the appendix itself and therefore to an increase in tension of that structure. If the appendix is kinked so as to obstruct the lumen or if a stricture from previous ulceration exists, the pain may be excessive due to a complete blocking of a portion of the appendicular lumen.

The sympathetic nerve-supply to the appendix is always the same.

These sympathetic fibres have their connection with the tenth and
eleventh dorsal segments, so that true appendicular pain is felt in
the region of the umbilicus. Should appendectomy be performed at
this stage, right iliac pain will never be present. Such an appendix
may contain intraluminal pus but the inflammation has not extended
to the parietal peritoneum.

After peritoneal extension the pain is felt in the right iliac fossa.
This is not appendicular pain but is the result of inflammation of
the subperitoneal tissues, the pain being an expression of irritation
of somatic sensory nerves and not in any way connected with the
sympathetic chain. If the appendix is located in other than its
classical position the secondary pain just as the second rigidity is
felt in the exact location of the disease.

In acute appendicitis the patient may suddenly be relieved of
pain and this is frequently interpreted by the physician as a good
prognostic sign. However, as DaCosta has so aptly said, this is
the calm before the storm, for it is the release of tension by perfora-
tion or the intervention of a gangrenous process which temporarily
relieves the tension and therefore the pain, the pain returning as the
parietal peritoneum becomes involved. On the other hand, the pain
may not be relieved, but the more severe pain of extensive parietal
peritoneum involvement may overshadow the true tension pain.
These are the cases of rapid progression in which the organisms
penetrate the coat of the appendix without an actual macroscopic
perforation being present.

As the result of visceral pain the abdominal muscles become ton-
ically contracted and the leg is drawn up on the affected side. This
reflex rigidity depends on the identical nervous innervation which
explains pain and it is for this reason that reflex rigidity in appen-
dicitis, as long as the inflammation remains in the appendix, is found
in the right lower abdomen. When the inflammation becomes diffuse,
rigidity will depend upon the extent of the peritoneal involvement.
Similarly, tenderness is found in a corresponding segment of the
central nervous system. However, since external pressure may irri-
tate the parietal peritoneum by bringing it into contact with an
inflamed appendix, tenderness may indicate more exactly the location
of this organ. This is seen in the retrocæcal appendix, which may

give posterior tenderness simulating disease of the kidney or the pelvic appendix which may simulate tubo-ovarian disease. When the examining finger on rectal examination causes severe pain, abdominal in character, it is due to an increase in the intra-appendicular tension since, should the pelvic peritoneum be inflamed, the pain will be localized in the region of the examining finger.

There has been a difference of opinion as to the amount of emphasis which should be placed on the leucocyte count. In our experience, variations in the leucocyte count have been as great if not greater than variations in the pain. In the last year, we have had several cases of acute appendicitis without peri-appendicitis in which the white count was over 20,000, while in two cases with diffuse peritonitis the count was less than 5000. We do not agree with Ochsner that the leucocyte count should be taken and looked at after operation. The latter procedure may be correct for the experienced operator, but it is certainly not to be followed by the tyro.

CASE I.—M. F., 36 years old. File No. 2154. Admitted to the wards of the University Hospital, October 6, 1923, complaining of excruciating pain in the right side. After careful examination, the pain was found to be chiefly in the right lumbar region with no radiation to the groin or testicle.

History of Present Illness.—The patient was in the usual state of health until this morning when he was awakened with some pain in the abdomen and excruciating pain in the right lumbar region. There was no blood on urination that he noticed. He had vomited twice during the morning.

Past Medical History.—Patient had had several mild attacks of abdominal pain in the last few months and some time ago had noticed some blood in his urine.

Physical Examination.—Adult white male suffering excruciating pain, looking somewhat shocked and definitely acutely ill. Abdominal examination showed distinct rigidity of the muscles of the right lower abdomen and the right flank, the latter being definitely more rigid. There was no distention. There was definite tenderness over McBurney's point, but the tenderness was more acute in the right flank.

The urinalysis was negative. Leucocyte count, 20,200. Patient's temperature on admission was 94.4° F., but after being in bed for a few minutes was 96° F. The pulse was 60. This was at 12 o'clock noon; by 9 o'clock the same night the temperature was 99.2° and the pulse was 104. Operation was performed at 9.40 P.M. At operation a thick, distended appendix was found in the retrocæcal position with very little evidence of any peri-appendicitis.

CASE II.—H. Z., 31 years old. File No. 2137. Admitted to the University Hospital, October 4, 1923, complaining of generalized pain and tenderness throughout the abdomen.

History of Present Illness.—For the last four or five months the patient has had mild attacks of fulness and discomfort in the upper epigastrium with belching following meals. Two days before admission, he was seized with sudden acute pain around the umbilicus. He was given calomel and magnesium citrate, both of which he vomited. Pain was diffuse throughout the abdomen and became progressively worse, gradually becoming more intense on the right side. General condition became rapidly worse.

Past Medical History.—Of no importance.

Physical Examination.—White adult male looking very acutely ill. There was exquisite tenderness and board-like rigidity throughout the abdomen. Peristalsis was practically normal. On percussion there was some apparent dulness in the right flank. Leucocyte count was 4300.

Operation.—Local anæsthesia. A large, gangrenous, perforated appendix hanging down over the brim of the pelvis was found. There was no evidence of any localization.

CASE III.—R. G., ten years old. File No. 796. Admitted to the University Hospital, January 2, 1923, complaining of pain in the right lower quadrant and vomiting.

History of Present Illness.—Three days before admission, she complained of pain in the abdomen and did not want to eat. While at school, she became sick and vomited twice and complained of cramp-like pain in the abdomen chiefly on the right side. Vomiting has been practically continuous for three days. Has had both cathartics and enemas.

Past Medical History.—Negative except attacks of abdominal pain for the last year.

Physical Examination.—Abdomen shows board-like rigidity of entire abdomen, tenderness over the right lower quadrant. Peristalsis was present. Temperature was 102; pulse, 130; white blood corpuscles, 3200.

Operation showed a gangrenous appendix which was perforated at about its middle with a diffuse peritonitis.

The first patient made an uneventful recovery while the succeeding cases died. The first case illustrates very well hyperreaction to an inflammatory lesion, while the latter cases illustrate an inability of the body to mobilize against an invading host.

There are two problems to consider when we discuss the surgery of the appendix; that in which the inflammation is localized to the appendix, and the other in which the inflammation has involved contiguous structures. The problem in the first group of cases is simple, for with early diagnosis and early operation the outlook is extremely favorable. The high mortality in appendicitis is due to the cases which fall in the second group. In this latter group there are several subgroups:

(1) Acute appendicitis with generalized peritonitis.

(2) Acute appendicitis with diffuse peritonitis.

FIG. 1.
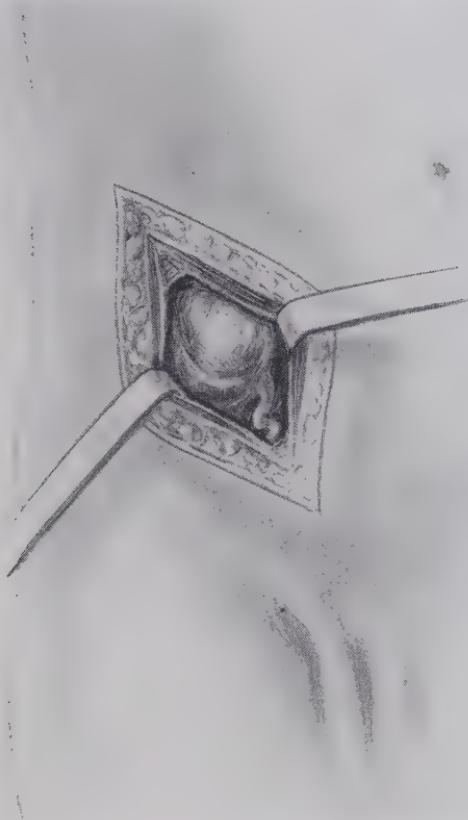
The McBurney incision.

Fig. 2.

The right rectus incision.

(3) Acute appendicitis with localized peritonitis or abscess.

(4) Acute appendicitis with retroperitoneal cellulitis.

The operative procedure depends upon the physical examination. It is an inviolable rule in our clinic always to use the McBurney or muscle-splitting incision in acute appendicitis (Fig. 1). The incision can be made in the high, low or classical position. Should it be found that the incision does not give adequate exposure, the lateral edge of the rectus sheath may be slit and the rectus muscle retracted. If the appendix is in the pelvis or if an error in diagnosis has been made, and the lesion is a pelvic one, the incision in the external oblique can be prolonged, while the internal oblique can be cut across and later resutured. An exposure such as this is equally as good as that given through the right rectus incision and the danger of post-operative hernia following drainage is less apt to result. Further-more, from the anatomical standpoint, the right rectus incision is not sound since it exposes large areas of the small bowel, and the infection, if not already diffuse, may become so. This is illustrated in Fig. 2, which was drawn by the artist after a right rectus incision on a cadaver.

The cæcum may be low, it may be high, or it may be in its nor-mal position, but it is never found in the midabdomen.

Where multiple drainage is necessary, we often do not suture the wound, or at most use one or two tension sutures in order to prevent a prolapse of the bowel. This is done with the full knowledge that a post-operative hernia may result, but it is our firm conviction that insufficient drainage has been the cause of many deaths, while a hernia is easily repaired.

In the case in which the diagnosis is made of a generalized peri-tonitis, it is a difficult question to decide whether we should or should not operate. These cases cannot be decided by putting a time limit from the inception of the symptoms. It is hardly proper to measure the progress of any intraperitoneal inflammation by the number of hours elapsing since the inception of symptoms. Thus, the time is only one factor to be considered with the symptoms and the physical examination. In the very late cases we have gone back to the non-operative treatment. For several years we followed the method of Crile of mere incision and drainage under local anæsthesia, but we

were unable to reduce our mortality. We cannot see the rationale of inserting one or more tubes in the right iliac fossa and pelvis since these cannot drain the entire peritoneal cavity, nor is the original focus removed. We therefore believe that if operation is resorted to, the appendix should be removed even though it necessitates a slight prolongation of the operation.

The decision of when to and when not to operate is a delicate one since often the gentlest manipulation seems to diminish what resistance there is in these cases. Narat, of Chicago, has recently suggested the use of intraperitoneal hypertonic glucose solution in these bad risk cases and this may offer some promise. The work of Costain, who has drained the thoracic duct in the neck, however, appears to be a more rational procedure for, if, as he claims, the major portion of the peritoneal drainage is through the thoracic duct, the method should be more universally adopted. In support of his work is that of Sweet done some years ago at this University, which showed that free blood introduced into the peritoneal cavity made its appearance in the thoracic duct within fifteen minutes. At the present time we treat these patients along the lines laid down by Fowler, Murphy, Ochsner, Alonzo Clark and Crile. We insist on a true Fowler position; the administration of enteroclysis of 5 per cent. glucose and $2\frac{1}{2}$ per cent. soda bicarbonate; continuous hypodermoclysis which contains 1/32 of 1 per cent. novocaine, as suggested by Bartlett; the intravenous administration of saline or glucose solution if enough fluid is not being absorbed by the previous two methods; the application of large hot moist pads extending flank to flank and xiphoid to symphysis; morphine in sufficient amounts to keep the patient quiet, and, of course, the total absence of anything by mouth. We have not favored the injection of large intravenous infusions. They are apt to overtax an already toxic myocardium. We believe it is safer to repeat smaller amounts, that is from 500 to 750 c.c., at frequent intervals. Glucose may be used together with insulin in order to supply carbohydrates for the increased metabolism. In some of the very bad cases, morphine was administered, as suggested by Crile, that is, at half-hour intervals until the respirations came down to twelve, and thereafter in sufficient amounts to maintain that respiratory rate. However, unless the nurses are trustworthy and watch-

ful, this is an exceedingly hazardous procedure.   In the cases of generalized peritonitis, peristalsis is generally absent and morphine to induce this is not necessary.   Furthermore, we feel that the reduction in the respiratory rate and the urinary output from the administration of large doses of morphine is often detrimental since these are important avenues of elimination.   In the majority of cases we have found it sufficient to give a quarter or a sixth of a grain at second, fourth or sixth hour intervals.

We do not mean to say that the patient must not have sufficient morphine to keep him quiet since we believe this is a very important consideration and at times when the morphine, when given as suggested, does not suffice, we have added scopolamine.

We believe that in the bad risk cases transfusion is an important consideration.   In this group we have been in favor of using whole blood instead of citrated blood.   The best results are obtained if the patients are bled and then immediately transfused.   Venesection and transfusion can be done at the same time or 500 c.c. of blood can be taken and 750 c.c. introduced into the same vein.   When this procedure is done, we are ridding the body of toxic substances and are injecting fresh blood with antibodies.

The treatment outlined has given us our best results in this type of case, appendicitis with generalized peritonitis, but in spite of careful treatment the mortality is still high and we doubt whether it has decreased materially in the last decade.

The next group is that to which belong cases of acute appendicitis with diffuse peritonitis.   We differentiate diffuse from generalized peritonitis by the fact that the physical signs are still chiefly limited to the right side.   You may say that this is a very difficult and hair-splitting distinction.   These cases, however, are not hard hit and the signs local and general are still favorable and not grave. While we feel that many of these patients would localize if treated by the Ochsner method, still we think it is safer to remove the appendix by immediate operation.   In certain of these cases it is dangerous to temporize with the Ochsner method since the peritonitis may be the result of a large perforation at the base of the appendix and the treatment must be that of a perforation of the gastrointestinal tract if the patient is to get well.   The patients are drained

and in draining we do not believe in sending a boy to do a man's work. Soft rubber tubes are used, because the firmer tubes may so easily cause a fecal fistula when placed against the very friable bowel. In placing the tubes in the pelvis, great care must be exercised in seeing that they lie against the lateral pelvic wall and not over loops of gut (Figs. 3 and 4), which latter position might result in post-operative obstruction. Several years ago we had the opportunity to observe a number of cases treated by the Robert Morris method. The method consists of appendectomy, the liberation of adhesions when they exist, mopping out the accessible pus and closing the wound without drainage.

It is true that drainage tubes perform their maximum work within the first twenty-four to forty-eight hours and it is also true that the promiscuous use of the drainage tube is actually harmful; still with the appendix removed, the amount of septic and toxic materials escaping in the first twenty-four hours may turn the tide and save the patient's life. We cannot see any necessity for breaking up adhesions since this only opens additional lymph-channels and allows for an increase in the absorption of the septic material. Subsequent adhesions must surely form and the procedure can do nothing but increase the risk to the patient. In fact, we usually welcome them since they are an indication of nature's effort to wall off a noxious agent and thus they act as the defense mechanism on the part of the body. After operation the same regime is carried out as in the first group and nothing is given by mouth until peristalsis has been re-established and flatus passed by bowel.

In acute appendicitis with localized abscess, operation should be performed as soon as the diagnosis is made. Surgeons who fail to observe this rule will see cases in which the abscess perforates into the free peritoneal cavity. We always use the extraperitoneal approach in these cases, as suggested by Deaver (Fig. 5), exposing the peritoneum to the medial side of the iliac bone, palpating the abscess and opening directly into it. If the appendix can be delivered without breaking up the limiting wall of the abscess, appendectomy should be performed. If, however, it forms part of the abscess wall, drainage alone should be instituted and the appendix removed at a later operation. In draining pelvic collections we at

Fig. 3.

The correct way of placing a drainage tube.

FIG. 4.
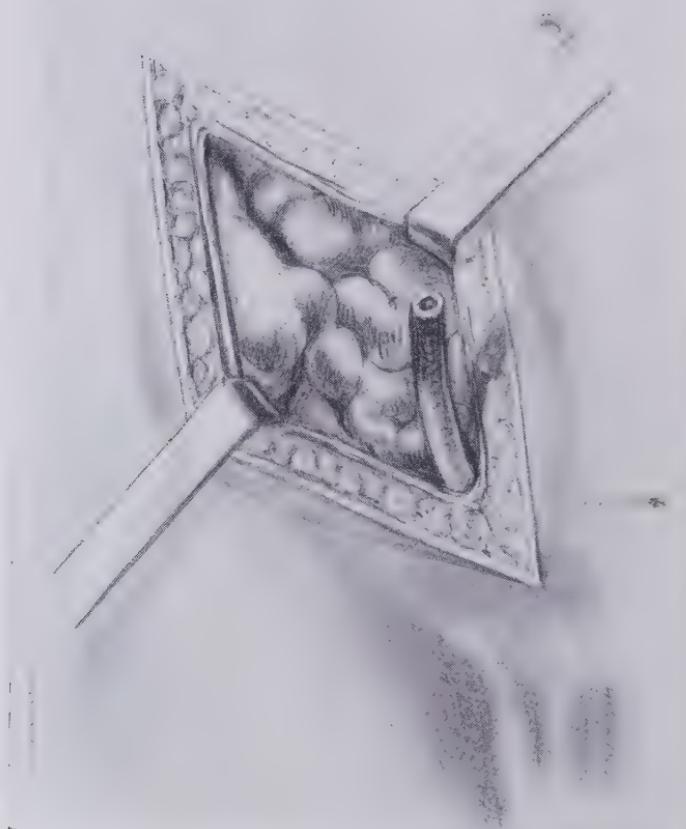
The incorrect way of placing a drainage tube.

Fig. 5.

Illustrating the extraperitoneal approach for an appendiceal abscess.

times resort to the vaginal or rectal approach. We feel that in doing this the collection is drained at its base and not at its apex. Each case must be studied individually, a routine procedure is hardly applicable in all. Should secondary collections occur, these should be opened under local anæsthesia or analgesia as soon as they are located. Failing to do this early may put the patient beyond the pale of hope.

Every surgeon has operated upon cases of acute appendicitis, found an acutely inflamed appendix, usually in the retrocolic position, with only a small amount of free fluid in the peritoneal cavity, but a red and œdematous posterior wall. The inexperienced operator is very apt to give a good prognosis in such a case but in our clinic we have found that the cases with retroperitoneal cellulitis caused the highest mortality in our operative cases. Regardless of the attempt at drainage, the retroperitoneal tissues usually are unable to wall off the injection and death ensues.

It is with this second group of cases that we are chiefly concerned. The ability to differentiate the subgroups is ofttimes difficult, but an attempt should be made in every case. Precipitate intervention with extensive exposures are not life-saving but life-destroying. We still see many of these desperate cases in our clinic and from the writings of others, I am led to the opinion that Philadelphia is not the only community which sees them. One must use judgment in deciding which cases should be operated on and which should be treated on the principle of physiological and anatomical rest. No definite rules can be laid down and those of you who attempt to operate by rule will make unfortunate mistakes. The hope for the future lies in operating on cases while the inflammation is local in character and not when contiguous structures have become involved.

INTUSSUSCEPTION

By RALPH B. BETTMAN, M.D., F.A.C.S.

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IT VERY frequently happens that cases of more or less rarity seem to come in groups and this fact is apt to direct special attention to the study of these cases. For this reason I have chosen to-day as the subject for my clinic, intussusception, having at present three cases under my care in the hospital. Although not a rare disease, it ranks among the less usual surgical conditions. For example, last year out of 9348 admissions to the Michael Reese Hospital, three cases of intussusception were recorded. Inasmuch as intussusception is a disease of childhood it might be more accurate if we based our judgment on the frequency, or rather the rarity, of its occurrence by its admissions to the Sarah Morris Hospital, the Children's Section of the Michael Reese Hospital, and we find that in 2119 cases there were three cases of intussusception. For the year preceding this, with about the same number of admissions, there were four cases and the year preceding that three cases. Thus among our admissions to the Children's Hospital the incidence of intussusception was approximately .15 per cent.

The histories show a striking similarity.

CASE I.—A six-and-a-half-months-old baby who had been well since birth suddenly, at 7.30 one morning, began crying as if in severe pain, drew up his legs as a child would who had a cramp, and vomited the feeding taken about ten minutes before. After a few minutes the child seemed more comfortable and went to sleep, only to be awakened in about half an hour by a repetition of the crying and the vomiting. He seemed very ill and it was on account of this that the mother became alarmed. She gave the child an enema and obtained a normal yellow stool. The child refused to nurse and went to sleep for an hour or so and then commenced crying periodically as if in pain. The mother called a physician who immediately advised sending the child to the hospital, and called me.

At about noon I made the following note: A well-nourished, well-developed child, lying quietly in bed, apparently acutely ill and toxic. Physical examination revealed no abnormalities except that a mass, soft, ill-defined, about the size of a walnut, was felt at the outer edge of the right rectus muscle at about the level of the umbilicus. A rectal examination revealed no abnormalities, but as the finger was withdrawn it was found covered with blood. Immediately after the

examination the child suddenly started crying as if in excruciating pain, drew up his legs, his abdomen became tense, and shortly afterward he discharged a bloody fluid mixed with fecal matter from the anus. The diagnosis of intussusception was, of course, clear.

The temperature was 100° F.; pulse, 132.

CASE II.—A little while later the second case came to my observation. The child had been brought to the hospital because of pain and vomiting. The day before admission it had vomited once in the evening, but inasmuch as he did not appear sick at the time the mother attached no significance to this attack.

This patient was a nine-months-old child who had previously been in very good health. On the day of admission he took his morning feeding normally. At about seven o'clock, according to the mother's statement, " The child began to cry as if in pain and drew up his legs like a cramp." The mother, thinking the child had a colic, gave him an enema but obtained no results. The attacks of pain, lasting from one to five minutes, continued intermittently during the morning. The mother became alarmed at the appearance of the child, called in a pediatrician and he advised that the child be brought immediately to the hospital.

The physical findings upon examination of this child were very similar to those in the first case. The extremely toxic condition of the child was striking. A soft mass was palpable on the right side of the abdomen, extending from under the right costal margin at the mid-clavicular line to about the level of the umbilicus. The rectal examination again was negative and again showed the rectum to be filled with bloody fluid. A diagnosis of intussusception was made.

The temperature was 101° F.; pulse, 140.

CASE III.—A nine-months-old infant had been apparently normal until the day before admission, when it was suddenly seized with what the mother described as a " cold chill " in which the child became extremely pale, cold, and covered with clammy perspiration. Almost immediately it doubled up with what appeared to the mother to be a severe abdominal cramp. This attack persisted for some time. After a few minutes the child vomited, the attack subsided, only to recur again in about an hour. A little while later a bloody discharge was passed from the rectum and in the next twenty-four hours the child passed eight bloody stools. Following the onset of the first attack the child had at least a dozen similar " cold chills." Everything taken by mouth was rejected, even water.

After twenty-four hours the parents realized that something must be the matter with the child and called a physician who sent the almost moribund infant to the hospital.

The examination of the child, as in the two other cases, revealed an extremely ill little patient and in this case the child was too apathetic to cry or remonstrate during the necessary manipulation of the examination. The abdomen was tense and distended. However, a mass could be made out at about the level and just to the right of the umbilicus.

The temperature was 101.4° F.; pulse, imperceptible. The diagnosis of intussusception was plain.

These three cases bring out distinctly the leading signs and symptoms of intussusception. The condition occurs usually in infants one year of age or under. Above the age of one year it is compara-

tively rare. The etiology is unknown. Occasionally it may follow conditions causing spasm of the intestinal muscles, such as diarrhœa, but as a rule, as in these three cases, it seems to come from a clear sky.

The onset is usually abrupt, although cases have been described where the presence of a bloody stool was the first symptom and in fact one case has been reported where the diagnosis was made during a routine examination in which a tumor mass was discovered in the abdomen.

The outstanding symptom is abdominal pain, the child usually manifesting the pain by crying, and the location of the pain by the tendency to pull up its little legs as in a so-called case of colic. Vomiting is usually a concomitant symptom, and as a rule is persistent. The vomiting is definitely not a regurgitation but frequently is described by the mother as actually projectile.

The bloody stool has been reported as being pathognomonic of the condition. A bloody stool is usually found; often the first two or three stools after the onset of the disease may be normal and then the bloody stool makes its appearance. The stool may consist of either pure blood, blood and mucus, or blood, mucus and fecal material.

The course of the disease is marked by a series of repeated attacks of pain. In the intervals the child may lie quietly, very often asleep, occasionally may even play. The appearance of the child varies. During the attacks it is evident that the child is suffering; after the acute attack the patient usually is apathetic, looks toxic and gives the impression of being extremely ill. A little later the child may recover to such an extent that his appearance is not alarming. Inasmuch as this condition is very apt to occur in healthy, well-nourished babies, the appearance of the child between attacks may be such that it is hard to realize that it is ill: The temperature may be normal, slightly elevated or subnormal. Temperature, therefore, is of little diagnostic importance in the early stages. In the later stages a high temperature may mean a beginning peritonitis or may be an indication of toxæmia and acidosis.

Physical examination of the child may reveal no abnormalities except that a mass, usually on the right side and somewhere in the

region of the cæcum, may be palpated. This mass usually is soft, rounded and conventionally described as " sausage-shaped."

Rectal examination usually is negative for pathological conditions. The examiner, because of the history of bleeding from the rectum, takes pains to look for a rectal polyp and usually finds none. The rectum is filled as a rule with the aforementioned bloody stool.

<div align="center">PATHOLOGY</div>

The existing pathological condition is a telescoping of one part of the bowel, usually the ileum, into another part of the bowel, either the ileum or the cæcum. Several different classifications of intussusception have been described, depending upon which part of the bowel was involved. The main types are, as a rule, however, the ileum into the cæcum, the ileum into the ileum near the ileocæcal valve and then into the cæcum, and sometimes the cæcum into the ascending colon. Inasmuch as it is often impossible, even at operation, to tell which part of the bowel was the starting-point of the intussusception, and inasmuch as it is of really little practical value, I do not think it wise to take up time in going further into the classification. Suffice it to say that the overwhelming majority of intussusceptions occur in the region of the cæcum, and that it is always the proximal part of the bowel which telescopes into the more distal part. The course is progressive. If the condition is allowed to remain untreated several inches of intestine may telescope. The blood-supply of the telescoped portion is interfered with on account of the tension on the mesentery, as well as the tension or pressure on the bowel itself. Necrosis will occur. Peritonitis develops. Intestinal obstruction is usually complete from the onset of the disease. Occasionally, however, especially in the cæcal colic type, the obstruction may not be complete at the beginning.

Many cases have been described in which a small tumor in the wall of the intestine at the site of the beginning of the intussusception has been found, and the intussusception has therefore been attributed to this growth. In the majority of cases, however, no such tumor mass is found. Occasionally a diverticulum, or a polyp, seems to be the start of the condition.

TREATMENT

The treatment is, of course, self-evident as soon as the pathologic condition is understood. The bowel must be untelescoped. This can be done only by surgical measures. Occasionally cases have been reported in which apparently an intussusception reduced itself spon-

FIG. 1.
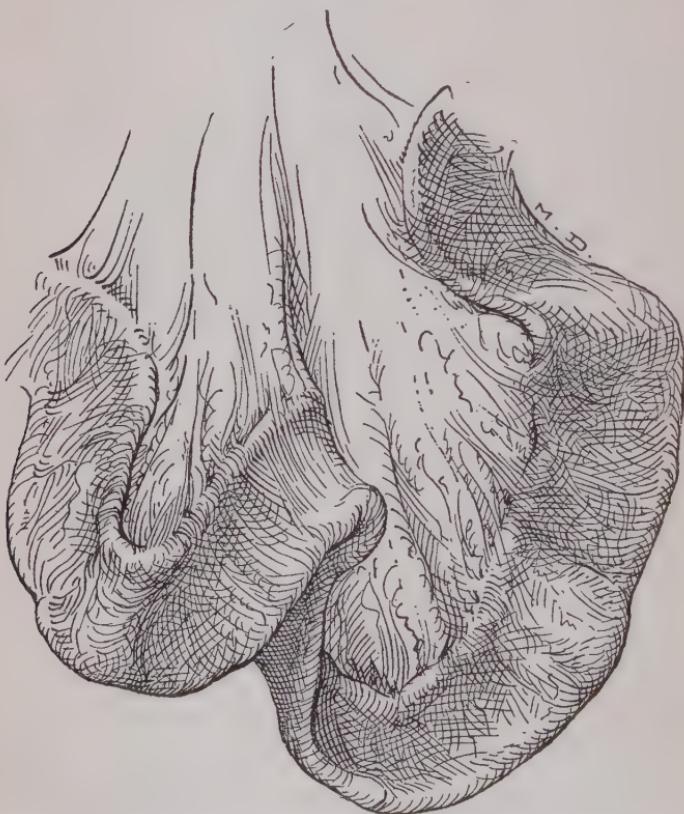
Drawing of collapsed area proximal to the intussusception as seen in Case II.

taneously. These cases are very rare and it certainly would be unwise to waste valuable time awaiting such an unusual procedure.

The time-honored method of reducing the intussusception by the inflation of the bowel with air is now in the discard. Attempts to reduce the intussusception by means of tubes passed through the rectum are futile. The only method which will reduce the intussusception is a manual reduction through a laparotomy incision.

The treatment in these three cases was similar. The patients were immediately taken to the operating room. A hypodermoclysis of 200 or 250 c.c. of normal saline was given in each case while the child was being prepared for operation. The incision was usually a right pararectus incision over the tumor mass.

An interesting finding was noted in the second case. I have seen the same thing occasionally in previous cases. The bowel above the intussusception, that is, the small intestine, instead of being distended as one might naturally expect, proximal to an intestinal obstruction, was very tightly collapsed, ribbon-like in appearance. Such a finding might lead an uninitiated operator to suspect that he had made a mistake in diagnosis and that the tight bowel lay distal to the obstruction instead of proximal to it. (Fig. 1.)

After the abdominal cavity is opened, the finger is gently inserted and the tumor palpated. If possible, two fingers are straddled over the distal portion of the tumor and with very gentle pressure the fingers are drawn downward, milking the intestine and thus reducing at times the intussusception. Then the tumor is grasped and brought into the wound, using as little traction as possible. Just as in every intestinal operation, gentleness must be one of the chief considerations. After the tumor has been delivered the intussusception is further reduced, not by pulling on the intercepted bowel or its mesentery, but by pressing on the tumor mass and thus reducing the condition by pushing the intussuscepted bowel outward.

The bowel is now carefully inspected to make sure that it has not been injured sufficiently to cause necrosis. A good method of examining the bowel is to restore it to the peritoneal cavity, allowing it to remain there for five or ten minutes, then to bring it into the wound again and see whether or not it has regained its normal color. In intussusceptions of long standing the bowel is often very difficult to reduce and in such cases resection at times must be done because the bowel has become so adherent that simple reduction is impossible. The mortality, of course, in these cases is greatly increased. Occasionally in long-standing cases bowel has been so injured that there would be danger of subsequent sloughing and perforation. Here also resection must be resorted to. Numerous procedures have been advocated to prevent recurrence of the intussusception, some of them are

shortening of the mesentery, suturing the gut to the parietal peritoneum, stitching the ileum to the ascending colon. Recurrences are rare, and apparently cannot be prevented by any of the methods so far described. Inasmuch as time is an important factor I do not deem it wise to add any unnecessary procedures to the operation, and therefore make no attempt to prevent recurrence. Of course, if I felt certain that any of the described methods would actually reduce the number of recurrences I would use it. In Case III after the intussusception had been reduced, the appendix which was involved in the intussusception was found to be very much injected and at its distal tip to have a small black area. Fearing its viability, it was decided to remove this appendix.

In Case II a similar condition was noted and here also the appendix was removed. Cases have been described in the literature of a coincidental acute appendicitis with intussusception. This condition might, of course, occur, but, as a rule, the pathologic changes in the appendix are due to the trauma of the intussusception and not to any other pathologic condition. The abdomen was closed in all cases without drainage.

AFTER-TREATMENT

The after-treatment is very important. These children have invariably been starved for a varying length of time, due to the vomiting, and the refusal to take nourishment. They are in shock, for the greater part they are dehydrated. For this reason it seems logical that one of the first considerations in the after-treatment should be to increase the body fluids. Inasmuch as large quantities of water are inadvisable by mouth and not well taken by rectum we have resorted to the transfusion of normal saline solution by hypodermoclysis. According to the age and size of the child from 100 to 200 c.c. of normal saline solution were given by hypodermoclysis four hours after operation, and repeated as often as indicated. Fluid in small quantities was started by mouth as soon as it was thought that the child would be able to retain it. Thus, in the first case, fluid was started four hours after operation and inasmuch as the child took the nourishment well was gradually increased until by twelve hours after operation the child was getting two drams of breast milk and one

dram of water, alternating every half-hour, and twenty-four hours after operation was put on a feeding of two ounces of breast milk every two hours with water or weak tea in addition.

In the second case it was possible to increase the fluid intake more quickly and in the third case likewise. The appearance of the first normal stool is, of course, positive evidence that the bowel is patent.

In Case I, twelve hours after operation, a brown semi-fluid stool was passed which contained a slight amount of blood and twenty-four hours after operation a thin green stool was passed containing no macroscopic blood.

In Case III no stool was passed for the first twenty-four hours. At that time, a proctoclysis of glucose and sodium bicarbonate was started and expelled after an hour with a small quantity of blood and no fecal particles. After thirty hours a large bloody stool was expelled with still no fecal material, and it was not until the beginning of the third day that a large dark fluid stool with fecal material and some macroscopic blood was expelled. In this case the first normal stool, that is, a stool in which there was no macroscopic blood, was not passed until the fourth day. However, the general condition of the patient, the fact that he passed from time to time small quantities of flatus and that his abdomen was not distended, relieved us of anxiety. I have mentioned in detail the time of the first stool in these two cases to show the wide variation in cases progressing favorably.

The remainder of the convalescence in Cases I and III was entirely uneventful. In Case II seven days after operation suddenly, while apparently in excellent condition, vomiting started in, marked abdominal distention was noted and the signs were indicative of an acute intestinal obstruction. The original wound was reopened, and a volvulus was found in the ileum about six inches from the site of the former intussusception. The volvulus was reduced, the abdomen closed and the child is making an uneventful recovery.

PROGNOSIS

The prognosis is difficult to establish. As a general rule, it can be said that it varies according to the length of time the disease has existed. As a rule, it can be said that the prognosis in cases of not more than twenty-four hours' duration is good, and after that is poor, and after two days it is bad. Exceptions occur. I have seen cases

of very short duration die apparently from profound toxæmia and other cases in which the bowel had to be resected get well. I have also seen cases of similar duration and similar pathologic findings in which one case recovered promptly and the other got well only after a very stormy convalescence. It is certain that the sooner the case is operated upon, the better are the chances for recovery.

The importance of early operation cannot be too strongly stressed. Bolling, in reporting a series of fifty cases about a year ago, with an operative mortality of 30 per cent., states that no patient died in whom symptoms had existed for less than twenty-four hours. The literature is filled with similar statements. No matter how far authors differ regarding the underlying pathology of intussusception, all are agreed that the earlier the operation the better the prognosis. Nothing can be gained by waiting. The establishment of the diagnosis should have as a natural sequel, immediate operation. It is fortunate that in most cases the symptoms are so typical, the history is so striking and alarming that there is little temptation to procrastination.

THE MANAGEMENT AND TREATMENT OF BRAIN INJURIES

By THOMAS MEARES GREEN, M.D., F.A.C.S.

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THE brain has always been the most vulnerable part of animal life. Perhaps this is why Nature has endowed it with a bony case to enclose its delicate structure. Man in his early existence as one of the smaller animals inhabiting the earth was forced to dwell in trees and cliffs, and to live in hordes, in order to protect himself against the larger animals. His brain then was only an organ to register sensation, and not the delicate structure it is to-day. But when he first grasped in his unarmed hand the stone to till the soil and to defend himself, he freed the brain from the slavery of being only an organ of sense perception, and made of it, through the development of the mind, the source of original impulses which were destined, not only to direct the function of all the other parts of the body, but to enable him to outstrip all the other animals of the world, and to develop himself through generations following into a creature of wonderful creative genius, well fitted to become the ruler of the earth. But with this higher development there also occurred an increased vulnerability, and necessarily an increased opportunity for the occurrence of physical injuries, not the least of which are injuries to the brain.

Historical medicine furnishes us with numerous evidences of operative attempts upon the skull, and, strange as it may seem, many to-day, even among our profession, speak in terms of " fracture of the skull " rather than of injuries to its contents. Not until we can shake off this obsolete idea of considering the " fracture of the skull " as the pathological entity can we ever hope to enter upon a realm of greater things in dealing with brain injuries; for with few exceptions the fracture of the skull has nothing to do with the treatment of brain injuries, the chief exception being depressed fracture of the vault. Often, indeed, the fracture serves as a saving grace by per-

mitting the cerebrospinal fluid and blood to escape from the skull into the scalp, and thus lower the intracranial tension, thereby relieving the pressure upon the cerebral cortex and the resulting damage to it. Among many, until recent years, and even to-day, the prevailing idea of treating brain injuries is limited to raising the depressed fracture of the vault and permitting the basal fracture to fight it out with an ice-cap and the *vis medicatrix naturæ*.

True, many recovered, or supposedly did, while those surgically treated showed practically the same mortality. Investigation of those who recovered without operation reveals a larger number of physical and mental derelicts with irritable cortex, failing vision, violent headaches, changed personality, and even epilepsy. These are now placed in the category of " wet brains." Many of these even at a late date can be reclaimed partially or in whole.

Failure of the operative treatment to show better results has been due largely to a lack of understanding of the fundamental pathological principles to be dealt with, which lead to a failure to recognize the proper time for operative intervention. To-day, however, by a definite understanding of these principles the mortality of operative cases has been cut in half, and if the moribund cases be eliminated it may be reduced as low as 17 per cent., at the same time eliminating almost entirely that large class of mental and physical derelicts who are known as " wet brains," and whose existence, as such, may be due almost entirely to a failure to apply the proper treatment at the proper time.

Naturally many brain injuries are fatal from the beginning, where fatal damage to the skull contents occurred at the very onset of violence, but of the other cases, those which are amenable to treatment, there has in late years been developed a technic of management which is simple enough for any painstaking surgeon to understand, and which, I am sure, will lead to a happy issue in a far greater number of cases than the textbooks would lead us to believe, *i.e.,* 68 per cent.

In this class of cases the symptom complex upon which we base our treatment revolves around the question of intracranial pressure. Formerly, with the exception of depressed fracture of the vault, we were taught that until the focal paralytic symptoms developed, no

operative interference should be attempted. Later an earlier method was followed, namely, that of observing the changes in the eye-grounds (with the ophthalmoscope), noting the presence of papillœdema or the early stages of beginning choked discs. To-day we know that few cases live to develop focal symptoms, and if we attempt operation in cases that have waited until choked discs have developed, our operative mortality will equal the 68 per cent. of the past or greater.

We have an instrument with which we can now measure the intracranial pressure in health, diseases, and injury, and through its use we are enabled to apply such treatment to these cases as to prevent in many patients the condition of medullary compression, medullary œdema and collapse. By means of it and the ophthalmoscope we have discovered that there are certain definite changes in the optic discs, which go hand in hand with increased intracranial pressure and which occur earlier than the choked disc condition. These investigations serve to confirm each other. Indeed when we find the eyeground changes progressing to the early stages of choked disc we invariably find an increasing intracranial pressure.

Constant examination of the eye-grounds following brain injuries, as well as animal experimentation, has shown that the successive steps leading to choked discs are:

(1) Engorgement of the retinal veins and decrease in the size of the retinal arteries.

(2) Blurring and obliteration of the outline of, first, the nasal, then the temporal side of the discs.

(3) Complete obliteration of the discs by œdema, and if this papillœdema measures above two diopters we have the condition known as "choked discs"; although this extreme condition of choked discs is rarely found in brain injuries.

A thorough knowledge of the cerebrospinal fluid is most important in the management of these cases. Anatomists have long known of its presence. In 300 B.C. Herophilus first discovered its presence in the lateral ventricles, in which place he thought the seat of the soul was located. In the seventeenth century, Middledorff removed it from the lateral ventricle through a trephine opening. In 1885, Corning, an American, removed it from the spinal canal by lumbar puncture, but most of our present knowledge emanates from the work of

Quincke, who perfected the technic of lumbar puncture as early as 1891, and began to apply its use to the study and treatment of diseases. The origin of the spinal fluid is not yet satisfactorily settled, but almost all physiologists to-day consider it to be a secretion of the cuboidal cells in the choroid plexus. The other theory is that it is a transudation from the perivascular structures of the central nervous system. Its chemical composition resembles only one other fluid of the body, that being the aqueous humor of the eye, with which it is almost identical. It was formerly thought no chemical bacteria, toxins or antibodies (protected or otherwise) could pass from the blood through the cuboidal cells of the choroid plexus into the cerebrospinal fluid, but to-day we know that this applies only in the normal condition. However, in diseases and where the choroid plexus has been irritated by spinal injections the cuboid cells allow these things to pass and to enter the cerebrospinal fluid. The amount of fluid varies from 60 to 160 c.c., 30 c.c. being in the ventricles. Its normal pressure is 5 to 9 mm. in adults and 4 to 8 mm. in children.

The fluid flows into the third ventricle through the foramen of Monro, and through the aqueduct of Silvius into the fourth ventricle from whence it escapes by the foramen of Luschka and Magendie into the subarachnoidal space, where it flows over the surface of the cerebrum, dips down into the sulci of the cortex and the cisternæ of the skull to bathe the deep recesses of the brain, finally passing along the cord into the spinal canal.

At present there are two views to account for its elimination. That of Weed, suggesting that it escape from the subarachnoidal space by filtration through the mesodermal cell membrane of the arachnoidal villi into the sinuses of the skull; while that of Dandy and Blackfan suggests that it is taken up by the stomata of exit in the walls of the supracortical veins of the entire subarachnoidal space, particularly those situated in the sulci and about the Pacchionian bodies along the longitudinal sinus.

Tumors and injuries frequently increase its secretion, while thyroid extract decreases its secretion. Any disturbance of its secretion or elimination interferes with the physiological action of the brain. It has been likened to the lymph of the body, but chemically does not contain waste products as lymph does, although it escapes into the

blood-vessels in a manner similar to lymph. The specific gravity is 1006, its reaction neutral, clear, odorless, tasteless and slightly more viscid than water. It does not coagulate and may contain bile or be turbid from infection or contain bacteria. Its H-ion concentration is equal to that of the blood, as is its urea content.

Symptoms.—Every case of head injury is attended by a greater or less degree of shock, the symptoms of shock being similar to those with which we have to deal in all traumata, nor should the treatment of shock vary in brain cases. In this condition we find the patient pale, cold, clammy, with a rapid pulse of 120 or greater; respiration 30 or more; systolic blood-pressure about 100, accompanied by wounds of the scalp and perhaps escape of blood and cerebrospinal fluid from the nose, ears or mouth. Later, if a brain injury is present and he comes from under the condition of shock, if he ever does, his pulse becomes progressively slower, as does the respiratory rate, until it is reduced to a pulse of 60, respiration of 18 and systolic blood-pressure rising to the neighborhood of 160. Here we have the patient passing from a condition of shock into one of irritability of the cerebral cortex with increased intracranial pressure, which may be due to increase in the amount of cerebrospinal fluid secreted, or to a delay in its excretion, or œdema, or hemorrhage, or to all of these factors. Spinal puncture at this time and the mensuration of the intracranial pressure would reveal a pressure above normal, about 16 or greater. At this time the superficial reflexes are exaggerated and there may be present the Babinski, Chaddock, Hoffman, Gordon, Oppenheim or Koenig reflex. Observation of the eye-grounds will reveal a blurring of the nasal side of the discs or perhaps of both the nasal and the temporal sides.

If nothing be done and the patient is allowed to go on in this condition he may enter into the very grave stage of medullary compression with a pulse of 50, sometimes as low as 40, respiration 12, choked discs, systolic blood-pressure 200, complete abolition of most of the reflexes, deep stupor with the beginning of Cheyne-Stokes respiration. Intraspinal pressure here will register about 20, sometimes as high as 40. From this condition he may emerge without operation, but will probably develop the later condition known as " wet brain," and become a mental and physical derelict.

If, however, he develops the further stage of medullary œdema and collapse, manifested by a sudden rise of pulse-rate to about 120 or more and definite Cheyne-Stokes respiration, appearance of papill-œdema of varying degree and temperature disturbances, death is the inevitable result. No operation or other treatment would save him now. Observation of the eye-grounds with the ophthalmoscope and careful notation of the rate of pulse and respiration and systolic blood-pressure, together with investigation of the reflexes and actual mensuration of the intracranial pressure will enable us to treat these cases with an absolute degree of certainty as to what pathological changes are going on in the head.

Treatment.—The definite treatment of brain injuries should be, first, to avoid the occurrence of as much shock as possible by applying heat, quiet, rest and small doses of morphine, just as in any other case of shock, first-aid to the scalp injuries, and no examination of the ears, nose or mouth for fear of carrying in infection. No operation should be attempted during the condition of shock, because it only adds more shock to the already injured patient. Unless he can survive the preliminary period of shock no other treatment would save him, nor should he be subjected to any of the special examinations at this time.

If, however, he does pass through the condition of shock and we find evidences of increased intracranial pressure with the spinal manometer and find with the aid of the ophthalmoscope a blurring of the nasal side of the optic discs, increased reflex activity or the presence of some of the special reflex activities, with pulse of 60, respiration of 18 and systolic blood-pressure of 160, then we have positive evidence of increased intracranial pressure, which, if allowed to remain, will in a large proportion of patients most certainly bring about the condition of medullary compression.

Here with the addition of quiet, rest and superficial heat, as during the period of shock, we add the ice-cap or helmet, small doses of opiates for restlessness and withdrawal of a sufficient amount of the cerebrospinal fluid to reduce the pressure to 10 mm., repeating this at intervals of twelve hours, we may tide him through without surgical procedure.

If, however, during this period of forty-eight hours, as deter-

mined by the ophthalmoscope and the spinal mercurial manometer, we find we are unable to keep the pressure at 16 or lower and with the occurrence of the clinical symptoms just mentioned, we must then resort to an operative procedure regardless of whether or not he has a depressed fracture of the vault or a basal fracture.

Operative interference consists of a subtemporal decompression on the right side in right-handed patients, if no focal symptoms exist, and *vice versa* in left-handed patients to avoid the motor speech area. The depressed fracture can be elevated after the decompression has been done or at a later operation. It should never be attempted before the decompression, if the intracranial pressure is as high as 16, because of the danger of the increased pressure pushing the damaged meninges through that area of the skull and thus producing laceration of the cortex.

There will be some cases which emerge rapidly from the period of shock into one of medullary compression with high pressure and definite eye-grounds, where palliative treatment would be useless. These cases all demand early decompression and invariably show rapidly increasing pressure and eye-ground changes. Or there are cases with rapid onset of increased intracranial pressure and rapidly advancing eye-ground changes due to large hemorrhages which should also be decompressed early, especially subtentorial hemorrhage. All depressed fractures should be elevated for fear of epilepsy.

THE DECOMPRESSION OPERATION

The subtemporal is best because it exposes the middle meningeal artery which is the vessel most frequently injured and, further, it is situated over the silent area of the brain. We have here a good pad of muscle and fascia to serve as a protection when sutured over the bone deficiency and, last but not least, it drains the middle cistern of the skull at its lower points, where most of the pathology occurs. It may be found necessary to do the procedure on both sides. So much for the treatment of acute brain injuries.

In chronic cases where injuries have occurred years before, or where depressed fractures of the vault have not been raised, or where we have dismissed a case because of the acute condition having cleared up under palliative treatment, there will occur disturbances of elimination of the cerebrospinal fluid, due according to Sharpe to the

blood which, having clotted over the surface of the brain, becomes organized as connective tissue about the walls of the supracortical veins and thus obstructs the venous absorption of the cerebrospinal fluid over a greater or less area of brain surface and thereby prevents normal elimination. These patients are classed as " wet brains." If we can demonstrate in them the presence of persistent increased intracranial pressure, as recorded by the spinal mercurial manometer, and eye-ground changes with constant headache, changes in personality, or epilepsy, we should unhesitatingly advise them to have the decompression operation done even at a late date and if present a depressed fracture raised in order that the cerebrospinal fluid may escape through the decompression area into the scalp and thus reduce the pressure.

The results in these cases may be striking even after years have elapsed from the time of the original injury. Apparently the slightest blow on the cranium of individuals suffering from a cardiovascular renal syndrome is sufficient to produce this condition of " wet brain." If an increased pressure can be demonstrated, several lumbar punctures will readily relieve it. If, however, these fail to relieve, a decompression would be in order. Intracranial hemorrhages occur in the new-born infant and may occur before, during or after labor. The symptoms of pressure here are generally delayed, but may present immediately if the hemorrhage is large. The symptoms are stupor, failure to nurse or to cry lustily or constant crying, bulging fontanelles, accompanied by spasticity of the muscles or reflex disturbances or even convulsions. Bloody cerebrospinal fluid is present if the puncture is done early, but it will be clear if the blood has been allowed to clot, only the serum then being mixed with the cerebrospinal fluid. This condition is often associated with premature labor and when the cord is wrapped around the neck. Drainage of the cerebrospinal fluid for the purpose of relieving intracranial pressure in infants where cerebral hemorrhage has occurred was first suggested by Doctor Sidbury, of Wilmington, N.C., although Doctor Green, of Boston, first found it present in convulsions of the new-born. It is the recognized treatment of to-day.

Several cases have recently been reported where blood transfusion into the longitudinal sinuses of older infants has caused intra-

cranial hemorrhage. In infants, however, the dura is elastic, which is not true in adults, and because of this elasticity of dura and the incomplete ossification of the bones of the skull the child's brain can withstand for a long time an increased intracranial pressure so that these cases may not show convulsive symptoms until three months or even a year has elapsed. For long they have been classed as spastic idiots. Ophthalmoscopic examinations will show a steadily increasing eye-ground change to the formation of papilloedema and the spinal manometer reveals pressure constantly above normal. Operative findings in late cases have shown large cysts over considerable area of the cortex, the product of blood-clots. These cases have been treated with thyroid extracts and other internal secretions and have been classified as cases of deficient ductless gland activity or as spastic idiots, due to no brain development or to arrested development from meningeal inflammation following acute infectious diseases. However, we know that when good has come out of this therapy, it is due to the thyroid extract given, which will decrease the secretion of the cerebrospinal fluid and thus produce temporary improvement. About one in five spastic idiots show increased pressure and these should be operative cases.

Operations will always improve spasticity and convulsions if only an increased pressure is present, but it will not regenerate a degenerated eye and not infrequently in late cases it does not help mental development to any great extent.

It necessarily follows then that the earlier this condition is recognized and the pressure removed, the greater will be the result attending and this is best accomplished when the hemorrhage has just occurred by lumbar puncture and withdrawing the blood till the fluid is clear; but in late cases by decompression. Late cases with a pressure which does not register above 12 are not considered good cases so far as the result to be obtained is concerned.

Who knows but what the high-strung, neurotic child that developed into a psychopath in adult life is not the product of an intracranial birth hemorrhage, whose brain has always been subjected to an increased intracranial pressure producing an irritable cortex? And yet there are many to-day who are so biased in their opinion as to refuse to do a lumbar puncture on a spastic idiot and check up with the ophthalmoscope.

A CLINICAL LECTURE ON OSTEOMYELITIS

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You have seen me operate during the last few months on a number of cases of osteomyelitis in various stages of the disease, and I want to take the opportunity to-day to attempt to present to you a distinct clinical picture of its course and its complications; for unless we can get into our heads a thorough understanding of such a disease as this, we will often be confused by the clinical characters of the cases as they present themselves to us, and will fail to recognize the proper stage of the disease, to institute the different forms of treatment that are required.

Osteomyelitis, by which, of course, I understand infectious osteomyelitis and more specifically that due to infection with the staphylococcus, or in rare instances with the streptococcus, is a disease which has been recognized in its entirety only within comparatively recent years. If you will look in the textbooks of a hundred years ago you will find very little about the subject. It was recognized theoretically that an inflammation of the marrow of the bone might occur, and it is recorded that even as early as the year 1798 Dr. Nathan Smith trephined a bone, which was the seat of acute osteomyelitis, for the purpose of drainage. Necrosis, which is a late stage of the disease, was recognized, but the most that our surgical forefathers of those days knew about the acute stage of the disease was that sometimes it followed injury to the bones in persons who already were in a " depraved " state of health. And although Ollier and Volkmann and some others, during the middle of the last century, recognized the morbid anatomy of the disease, it was not until after the introduction of bacteriology that its cause was understood, and not until the present century that the pathogenesis, or the mode of onset, was well known.

In studying any disease it is well to begin with observation of facts, and when these have been thoroughly observed then it is time, and not until then, to theorize about the facts and try to explain them by laboratory methods and by further observations. Now the facts

are that acute infectious osteomyelitis arises usually in growing children who give a history of some injury, frequently not a very severe one, to the bone which is subsequently affected. In a great many cases careful inquiry will elicit a history of some infection—some *general blood infection*—having preceded the injury; but this is not always the case, and to explain the localization of an infection in the injured bone it is sometimes necessary to assume that there has been a general blood infection, although this cannot be determined from the history. Furunculosis is one of the most frequent infections which precede the onset of osteomyelitis. It also follows festering sores which result from neglected (because trivial) burns; it sometimes follows the exanthemata; and a very distinct and characteristic form of disease follows infection with tuberculosis. It might also be said that in advanced stages of carcinoma the bone-marrow sometimes becomes infected with carcinomatous osteomyelitis.

The causes of all of these diseases, which seem so diverse one from the other, nevertheless are believed to reach the bone in the same way, that is to say, through the blood-channels, although in carcinoma this is a matter of dispute. Then you see it becomes necessary to understand the blood-supply to the long bones. This was studied by Lexer about twenty years ago by injections with a substance opaque to the röntgen-ray, and he demonstrated that the bone receives its blood-supply from three main sets of arteries. There is, first, the nutrient artery which enters the long bone about the middle of its shaft, divides into two main ascending and descending branches, and these ramify within the marrow as far as the epiphyseal cartilages at each end of the bone. The second source of blood-supply consists in small arteries which enter the cortex of the bone on the shaft side of the epiphyseal cartilages. These also terminate near the epiphyseal cartilage. Finally, there are little branches which enter the epiphysis of the bone itself, and they also send their terminal twigs toward the epiphyseal cartilage: So that no matter by which of these three channels of approach the bacterial embolus enters the bone, it lodges somewhere near the epiphyseal cartilage, and the chances are more than two to one that it will lodge on the shaft side of the epiphyseal cartilage, because not only are there two sources of blood-supply through which the embolus may reach this situation, but the current of blood which

reaches the shaft side of the epiphyseal cartilage is very much greater in volume than that which reaches the epiphysis itself. Moreover, in infancy and young childhood there is very little blood reaching the epiphysis, as this is composed largely of cartilage, which is lacking in blood-supply.

So far this has been only a mechanical explanation of why the disease of osteomyelitis begins in a portion of the shaft of the long bones called by Ollier the " juxta-epiphyseal portion," and by Kocher, the " metaphysis "; but there is another explanation: This is that the bacterial embolus reaching the bone, for instance, through the nutrient artery and entering the marrow cavity, will be shot along in the blood-current with great rapidity until it reaches the end of the bone in which the red marrow is situated. Here all of a sudden the blood-channels widen out, the blood-current slows down, and there is semi-stagnation of the current, especially if the bone has been injured and there is already congestion from inflammatory reaction. For, as Ollier says, the numerous falls which children experience cause, in the juxta-epiphyseal portion of the shafts, crushings, trabecular fractures, separations of the periosteum, and so forth. So that in this slowed current of blood, which meanders peacefully through the ends of the bones, the bacterial emboli drift off to the sides of the blood-channels and lodge on their walls in the same way that Piney has recently described the cancerous emboli lodging in the same situation; and they do it for the same reason, which, after all, is a mechanical one. Now these bacterial emboli which reach the interior of the bone in this way, and lodge somewhere in the cancellous tissue of the diaphysis, have come there from a primary focus after traversing a large part of the patient's body. They must have been first absorbed by the veins, carried through the heart and lungs, and sent out again into the peripheral arterial circulation. It is no wonder then that a great many cases of osteomyelitis of a severe type give evidence of septicæmia and that they have multiple foci of infection. Not only may the same bone be affected in more than one place (the bipolar osteomyelitis of Ollier), but several different bones may be affected, and in severe cases there may be pyæmic abscesses in other parts of the body. I have seen one boy who had foci of osteomyelitis in his mandible, both ulnæ, and both femora; another who had pyæmic

abscesses in the soft parts in ten different places over his body, and a bone focus in one fibula; all of these foci and the blood also contained staphylococci. The following case is a typical example of unrecognized multiple foci.

CASE I.—*Pyæmic Abscess of Anterior Mediastinum, with Osteomyelitis of Femur and Fibula.*—Mary B . . . . . , who was thirteen years old, was brought to the Episcopal Hospital in March, 1915. About six weeks previously she had had an abrasion of her left ankle. One week later she complained of pain in her right thigh above the knee. For several weeks she had been treated at home for rheumatism, and was finally sent to the hospital, with the suggestion that massage be employed. She was thin and anæmic, but said she had been eating well, but had been unable to sleep for many nights because of pain.

There was an unhealed abrasion on the left ankle, an abscess pointing over the second right costal cartilage, and a large deep abscess on the inner side of the right thigh above the knee.

The abscess over the sternum was opened, and found to arise in the anterior mediastinum, whence about 250 c.c. of pus were evacuated. Incision of the thigh gave exit to more than 500 c.c. of pus from beneath the periosteum; the femur was opened and its marrow found full of pus. The girl rapidly improved, but several months later developed subacute osteomyelitis of the left fibula. Only cortical sequestra formed in the femur.

As far as we have gone in the description of the onset of osteomyelitis surgeons in general are in agreement; but there is some disagreement, not to say dispute, among them as to what occurs next. Some teach that these bacterial emboli lodge in the cortex of the bone close to under layer of the periosteum, and that the subperiosteal infection, which is so frequently seen in cases of acute osteomyelitis, may be regarded as a primary disease owing to the very superficial character of the infection of the bone. This, I believe, is erroneous. Most surgeons still hold that in the large majority of cases the bacterial emboli lodge deeper in the cancellous spaces of the bone, and that nearly invariably before they spread their infection through the cortex to the subperiosteal tissues they have produced considerable infiltration of the cancellous bone inside of the cortex (Figs. 1 and 2), and that in the majority of cases there is great danger that the infection will spread into the true marrow cavity of the bone instead of merely coming to the surface and draining the infection into the subperiosteal tissues. As the bone depends for its nutriment and subsequent existence on its blood-supply, and as the infection of the marrow tissue very easily leads to thrombosis of vessels and anæmic necrosis of the bone (Fig. 3), owing to the impossibility of swelling taking

place, it is evident that it is important to relieve this tension at the earliest possible moment that the disease can be recognized. The purulent infiltration within the bone and the pus which forms, as I believe secondarily, beneath the periosteum will, if not given free drainage, very soon destroy a considerable portion of the shaft; and this, unfortunately, is the stage in which many of our patients are first seen (Fig. 4). If the disease is left to itself the bone usually becomes perforated in one or more points with a perforation of such size that it is readily recognized when the bone is exposed; and by this time, or even before, the periosteum ruptures and the abscess invades the soft parts, forming what is called a *parosteal abscess*. This may even make its way out through the skin and discharge itself spontaneously, causing a temporary quiescence in the disease.

CASE II.—*Acute Osteomyelitis of Humerus Mistaken for Typhoid Fever.*—Margaret A..... was sixteen years of age, and was treated during August and September, 1919, for typhoid fever. After the most acute symptoms began to subside it was noted that her right shoulder, which had been very painful for some time, was quite swollen. While her physician was debating with himself what to do about it, an abscess formed over the upper part of the humerus. This he lanced. Subsequently other sinuses formed lower on the arm.

She came under my care at the Episcopal Hospital in the following February, with extensive necrosis of the upper end of the humerus; two large and several small cortical sequestra were removed, the dense involucrum which covered them was excised until only the posterior wall of the bone remained, the cavity was sterilized so far as possible, and filled with iodoform bone-wax, and the soft parts closed over it without drainage. Though some of the wax exuded between the stitches, at the end of nine weeks the wound was entirely closed, and it remains healed to-day, nearly four years after operation.

After the acute stage has subsided there begins to be formed beneath the raised periosteum a layer of new bone springing from the old cortex. This involucrum will ensheath the necrotic cortex (sequestrum) more or less completely, the small points where the involucrum is deficient being known as *cloacæ,* or sewers, through which the pus from the dead or dying bone finds its way to the surface. At the same time new bone will be formed on the marrow surface of the old cortex from the endosteum, provided this has not been destroyed by the disease or by the surgeon. The new subperiosteal bone will remain soft and plastic for a number of weeks (Fig. 5), but eventually it becomes harder and harder until, when the disease is very chronic, it may be so hard as to break the surgeon's gouge

(Fig. 6). Thus, in the favorable cases the sequestra which arise are more or less flake-like in form, and if the cortex regenerates well beneath them, from relatively intact endosteum, these "cortical sequestra" may be discharged spontaneously, or may be removed by the surgeon with very little disturbance of the soft parts or bone, and the patient will soon be cured. But if the endosteum has been destroyed by the primary disease, or by too vigorous interference from the surgeon, only an involucrum will form, and the cortical sequestra composed of the entire thickness of the original cortex

FIG. 7.
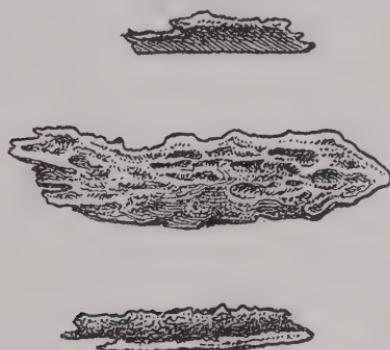
Cortical sequestra. These are formed on the surface of the old cortex, either because its entire thickness has not, in the first instance, become necrotic, or because the underlying endosteum which lines the marrow spaces has been able to cause regeneration of a cortex with perhaps partial absorption of the deep layers of the cortical sequestra. The sequestrum in the centre of the figure has its deep surface exposed. Note its worm-eaten appearance, compared with the smooth superficial surfaces of the other sequestra. These smooth surfaces faced the periosteum.

will lie in a distinct bone cavity. Still more serious are the cases where necrosis of an entire section of the bone arises, forming the so-called tubular sequestrum (Figs. 7 and 8). These tubular sequestra are rarely or never discharged spontaneously. When this stage has been reached—the stage of *sequestration* and *involucrum* and *cloacæ* —the affection is known as "necrosis," and it is this stage only that you will find recognized in the teachings of one hundred years or even of fifty years ago. The preceding stages were admitted theoretically, but they rarely if ever were recognized clinically in time for proper treatment to be instituted.

As I have said, it is very important to recognize as early as possible the symptoms of this disease, but it is not always very easy. In the hyperacute cases the symptoms of the general infection may so overshadow those due to any local reaction that the latter will be

overlooked; and I have no doubt that many patients who are said to have developed osteomyelitis after or during an attack of typhoid fever have really been suffering from osteomyelitis from the very beginning, and the typhoidal symptoms have so obscured the local condition that it passed unrecognized until the presence of pus beneath the skin was undeniable (Case II).

The hyperacute cases are very serious. Nearly all the patients die. Taking together what may be called the hyperacute and the acute cases, it is probable that the mortality of the disease is at least 25 per cent. Even the subacute and chronic cases leave lasting disability, with usually many recurrences during the life of the patient, even if he does not constantly carry a discharging sinus.

The recurrence of the disease is a curious feature. Either we must believe that the staphylococci lie dormant for many years at the site of primary infection in the bone, or that they lie latent elsewhere in the body and are brought again to the former seat of disease at any time that this is injured, even if it be many years subsequently. I have had one patient under my care who had no trouble at all with his tibia for twenty-seven years after my father operated on him; during all this time his tibia had remained healed and given him no trouble. Then he bumped it, and in a very few days began to have pain and then developed a chronic bone abscess. More remarkable still is a patient to whom Ollier refers, whom he saw at the age of seventy-five years, with a recurrence in a limb which had been symptomless since the man had been thirteen years of age, that is to say, over a period of sixty-two years. Not only may the disease recur at the seat of primary infection, but it may break out in a new place following undue strain or injury.

CASE III.—*Osteomyelitis of Femur Invading Hip-joint—Excision of Hip for Drainage.*—Sinus for three years. Nearly four and one-half years later, developed subacute osteomyelitis of humerus following injury. Edward B....., twelve years of age, was under my care in the Episcopal Hospital in August, 1919, for acute osteomyelitis of the left femur. The first operation, by another surgeon, consisted merely of drainage of an abscess in the soft parts in the adductor region. For persisting sepsis, I guttered the upper end of the shaft of the femur, and, opening the hip-joint, found it full of pus, and the head of the femur detached as a sequestrum. It was removed, together with the neck and trochanters, which were necrotic. Fair regeneration of the neck occurred, and though the wound did not close permanently for three years, he secured a stable and perfectly useful hip-joint, though with considerable limitation of motion.

In December, 1923, he returned with subacute diffuse osteomyelitis of the shaft of the right humerus; the symptoms followed a few days after being punched in the arm by one of his playfellows.

The patient, usually a child, gives a history, which I have indicated, of moderately severe local injury, and within a few days or weeks thereafter the disease suddenly develops, or the patient gradually becomes conscious of the fact that one of his limbs is diseased. Many of the patients with subacute or acute osteomyelitis that I have seen have been treated at home for some time for rheumatism. The patient whose case I have related above as Case I was sent into the hospital for massage, although at that time she had advanced pyæmia with an unrecognized osteomyelitis. But the disease is not one affecting the joints, and if the patient is attentively examined this fact can soon be determined. There is a disease in infants which has been called " acute epiphysitis " and which was described many years ago by Mr. Thomas Smith under the title " acute arthritis of infants," but I am about convinced that this is nothing more than osteomyelitis invading the joint. I do not believe that there is any proof that the primary infection in these cases arises in the epiphysis of the bone. The fact that the epiphysis becomes detached and may be absorbed and the patient recover after incision and drainage, or after spontaneous opening of the abscess, is merely proof to my mind that the primary infection, which arose on the shaft side of the epiphyseal cartilage, broke into the joint cavity, and thus caused disorganization of the joint. The condition is most frequent at the shoulder and the hip where the epiphyseal cartilage lies principally or entirely inside of the joint cavity, and where an infection on the shaft side of the cartilaginous plate is very apt to invade the joint. I have seen a number of children with pathologic dislocation of the hip, with a history that they had an acute illness in infancy, that an abscess discharged, or was lanced, in the region of the great trochanter, and that when the acute disease subsided the limb was found shortened and the joint dislocated. I have seen only a few cases in the acute stage. In one case (an infant aged eight months) the disease, affecting the shoulder, had been mistaken for scurvy; but incision showed that the bone was diseased on the shaft side of the epiphyseal cartilage, and that the head of the bone was lying loose in the shoulder-joint as a

sequestrum; prompt recovery ensued when the sequestrum was removed and the bone and joint drained.

Whenever a child gets a disabled limb with fever and malaise and pain think of osteomyelitis, and if you think of it you will rarely overlook it. Look at the joint and you will find that it is normal or so nearly normal that its implication in the disease remains in doubt. Look at the bone and compare it with the bone of the other side. You will find that the limb is swollen and that almost any motion will give it pain. Palpation is very painful, more so at one end of the bone than at the other. There may be no redness or there may be a redness which will closely simulate erysipelas or cellulitis, but both of the latter conditions are very apt to spread beyond the neighboring joint, and this is not the case in osteomyelitis where the symptoms in the soft parts are limited to the area covering the diseased bone. If any doubt exists as to the diagnosis I am sure it is much safer to cut down and look at the bone than it is to postpone operation in the hope that something will turn up. In one baby fourteen months old, in whom I thought the affection was erysipelas, but could not be certain, I had no compunction at all in cutting down upon the tibia, incising the periosteum, turning up a chip of bone with a gouge, and looking at the marrow. I found nothing wrong with the periosteum or the bone, or the marrow; and not only did the operation do no damage to the bone, but it actually seemed to do the erysipelas good.

Like all the other infections, osteomyelitis may be not only hyperacute, acute, or subacute but also chronic, and with varying degrees of chronicity. It may be so chronic and so indolent, so latent and so unrecognized that several years may elapse before the patient comes to the surgeon, merely complaining through all this period of rheumatic pains in the leg, unrelieved because no spontaneous fistulization has occurred. I operated upon one such boy, about fifteen years old, who had been treated for rheumatism for two years, and I found newly formed subperiosteal bone about 1.25 cm. thick covering an old hard sclerotic shaft of the femur which was necrotic throughout almost its entire extent. In such cases the pain, which may finally become intolerable, is usually very easily relieved by drilling the bone in two or three places. Although the infection may be so slight as to

give no growth when a smear is cultured there can be little doubt, I think, that such cases are of infectious origin.

CASE IV.—*Chronic Osteomyelitis of Femur; Pain Relieved by Drilling.*—Abel H . . . . ., thirty-eight years of age, gave a history of having had an operation eighteen years previously, and a second operation seven years previously for osteomyelitis of the right femur. He had suffered frequently from furuncles, but until two months before I saw him, in consultation with Dr. G. M. Astley, he had had no further symptoms of disease in his femur. During these last two months, however, pain had returned, becoming finally intolerable, and accompanied by a low irregular fever. Incision on both sides of the thigh, above the femoral condyles, disclosed apparently normal bone. A 5-millimetre drill was run into the marrow from each wound; only blood was obtained on the median side, apparently a little pus from the lateral surface. A drain was placed down to the bone on each side; cultures of the matter exuding from the drill-holes gave no growth, but the man's pain was relieved almost immediately, his fever stopped, and less than two weeks later he was sent home in perfect comfort, and able to bend his knee nearly as well as before the onset of the present illness.

Some of these chronic cases are syphilitic, but, as a rule, syphilitic osteomyelitis may be recognized by other symptoms of syphilis, the different history of the disease, by the X-ray examination, by the help of the Wassermann reaction, and even in the absence of this by the value of antisyphilitic treatment. Yet syphilitic osteomyelitis may become secondarily infected with pyogenic cocci through the bloodstream or through a sinus; and an acute gumma situated on the surface of the bone may very closely resemble a subperiosteal abscess, and it may not be until it is incised that the surgeon becomes aware of the true nature of the disease.

The treatment of the disease, I repeat, requires prompt and accurate diagnosis. In the most hyperacute type it is true that scarcely any patients survive long under any form of treatment, but if the local focus can be recognized in bone I think it is proper even in such cases to make the attempt to save the patient's life, even though the prospect of cure may seem very small. Such a case, for instance, as the little boy on whom you saw me operate a few weeks ago, seemed hopeless from the start, and yet I felt justified in opening the child's femur.

CASE V.—*Acute Osteomyelitis of Femur of Three Days' Duration; Death.*— Howard W . . . . ., five years of age, was sent into the Episcopal Hospital on the morning of October 13, 1923. He had complained of pain in his right knee on the morning of October 10th, but went to school as usual. He came home feeling worse, with a marked limp, and with his lower right thigh swollen. His father,

who was a druggist, treated it with Epsom salts locally, and as the boy got no better, sent for his family physician on the evening of October 12th. The physician may have suspected he had to do with a case of acute osteomyelitis, but he was not sure enough until the next morning to urge immediate operation.

On admission the child was extremely septic, lethargic, and cyanosed. The right thigh was immensely swollen from hip to knee, but the joints themselves were not diseased. Incision along the outer side of the thigh above the knee showed the soft tissues under such tension from œdema that not a drop of blood was seen. There were dirty serum and flakes of pus beneath the periosteum; the marrow tissue was grayish-red and infiltrated with pus. The culture showed a growth of *Staphylococcus pyogenes aureus*. Death occurred about twelve hours later, after a temporary improvement from stimulation and forced introduction of fluids by all available routes.

If patients could be seen at the earliest stage of the disease a very simple operation would suffice to cure them. Through a small incision the bone end may be exposed, the periosteum reflected over a very limited area, and a small trephine opening or drill opening made into the bone just on the shaft side of the epiphyseal cartilage. If the first drill-hole does not reach pus or inflamed marrow, a second and a third may be made close at hand. Then all that is necessary is to put a rubber tissue drain down to the surface of the bone and close the soft parts about it. It is due chiefly to the teaching of the late Dr. George A. Peters, of Toronto, that such minimal interference in very early cases has come to be recognized as sufficient; and I cannot commend you to any better description of the disease than is to be found in his monograph included in the "American Practice of Surgery," edited by Doctors Bryant and Buck (1907).

But cases as early as this are rarely or never seen. In almost every patient the disease has so far advanced when first seen that death of a certain portion of the bone is a necessary consequence; and after the first operation, which is done merely for drainage of the bone, at least one more operation will be necessary to remove the sequestra. If the first operation succeeded in draining the bone efficiently only cortical sequestra will form, and these may be removed as soon as they are detached, usually in the course of six to ten weeks, and then the wounds may heal without further interference; but if the first operation has been inefficient, by which I mean either too limited in extent or too radical, then a larger portion of the bone will become necrotic, and a second and perhaps a third formal operation will be required for the cure. It is unnecessary and undesirable at

the first operation to strip the periosteum too widely, because this will predispose to the death of the bone. On the other hand, it is desirable to detach it from a sufficient area of bone to enable one thoroughly to expose the diseased marrow and to give the latter free drainage. I do not at all believe that those surgeons are right who teach that at the first operation nothing should be done except to incise the periosteum and drain down to the cortex of the bone. They are of the opinion that nothing that the surgeon can do to the bone will alter the course of the disease. They claim that in a little more than half of the cases incision of the periosteum is sufficient, and that in most of this number all that will subsequently happen will be the detachment of small cortical sequestra. In the other half of the cases they claim that a tubular sequestrum involving the entire circumference of the bone will form no matter what is done; but certainly in my own experience the development of a tubular sequestrum has been the exception rather than the rule; and if leaving the bone alone will result in the formation of a tubular sequestrum in at least one-half the cases, then I am all the more convinced that by opening the bone at the first operation you will prevent the formation of a tubular sequestrum in the vast majority of cases.

So then, to summarize the treatment of these cases, let me take first a typical acute case. If in such a case we incise the periosteum only and drain the abscess which is beneath the periosteum, it is barely possible if there is no medullary involvement that the patient will recover without further interference; but in almost all cases at least cortical sequestra will form, and inasmuch as it is impossible to know whether there is any medullary involvement or not unless the bone is opened, I believe it should be opened *in every case*. If no medullary involvement is found, no harm will have been done and recovery will proceed as if the bone had not been opened. If, on the other hand, medullary involvement is present, nothing need be done at the first operation except to secure free drainage for the inflammation inside of the cortex. Almost without exception I have found pus within the marrow at the first operation; and enough of the cortex should be removed by gouge and mallet to uncover all the purulent content, even if to do so should lead the surgeon throughout the greater part of the shaft; but the earlier the case is seen the less

extensive will the involvement be, and only a short distance near the epiphyseal cartilage may require to be opened. This operation has been called by the French, *évidement,* and may be Anglicized as *guttering.* This is enough to do at the first operation; the marrow tissue should not be cureted, but should be left alone; if not disturbed many of the osteogenetic cells in the endosteum will survive, and eventually will aid in repair. The soft parts are held aside by a light packing of gauze and the wound is dressed from time to time until the patient becomes convalescent; usually within a week or ten days the temperature will become steady and convalescence will be well established.

CASE VI.—*Acute Osteomyelitis of the Ulna Invading the Elbow-joint: Guttering Followed by Subperiosteal Resection of Ulna; Complete Regeneration* (Figs. 9, 10 and 11).—Martin T . . . . ., twenty-seven years of age, was operated on by my associate, Dr. Edward T. Crossan, August 13, 1920, for drainage of an acute osteomyelitis of the left ulna. Doctor Crossan removed a sequestrum from the upper end of the ulna, and guttered the shaft from the olecranon downward. A fracture of the ulna occurred about its middle. A week later (August 20, 1920), because of continued hectic fever, indicating imperfect drainage, I had the man taken to the operating room again, and under nitrous oxide and oxygen anæsthesia I lengthened the incision all the way to the lower end of the ulna. There was pus in the marrow as well as subperiosteally throughout the length of the shaft. The entire lower end of the ulna was necrotic and was removed subperiosteally; and the upper end of the ulna (olecranon and coronoid processes) and the head of the radius were excised, as the elbow-joint was full of pus. The articular surface of the humerus was eroded, and probably would require removal later, but I thought it better not to do too radical an operation while the patient was still acutely ill; free drainage was the most important thing. There remained of the ulna, besides its periosteum, only its head next the wrist-joint, and a fragment of its flexor surface extending down about 12 cm. from the elbow-joint. The wound was loosely packed with iodoform gauze and a rubber tissue drain was inserted into the elbow-joint, and the limb dressed on an internal angular splint.

The patient did very well for about five days, his temperature keeping nearly normal and steady. Then there was a sudden flare up to 104° F., and for several days his temperature ran a hectic course without my being able to find any cause for it. Then his arm became boggy over the flexure of the elbow and the internal condyle; and on September 1st, under gas, I made counter-incisions in these situations, finding about 10 c.c. of creamy pus burrowing up along the course of the brachial vessels. Three small rubber tubes were introduced, one into each of the new incisions, and one across the elbow-joint from the old posterior granulating wound. The hand and lower forearm were in good condition, and the wound was healing at its lower end. Eusol was injected through the tubes every two hours.

From this time on the healing was uneventful. Fig. 10 shows the condition two months after resection of the ulna, and Fig. 11 shows the complete regeneration of the ulna. The elbow became ankylosed at an angle of 150 degrees. He lost

FIG. 8.
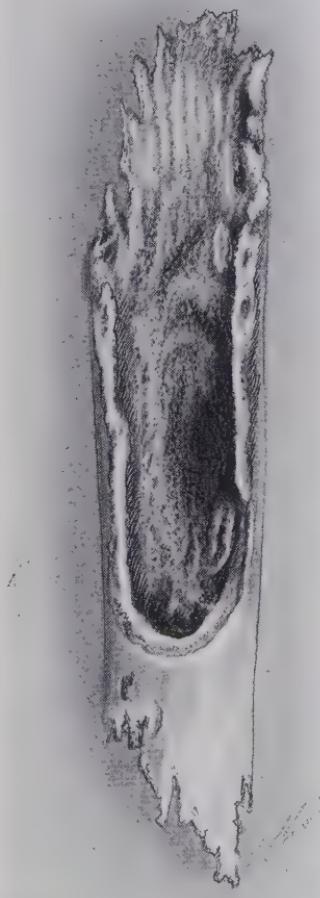
Tubular sequestrum from the upper end of the tibia. At the first operation the cortex was opened by a trephine and on exposing pus within, the opening was enlarged with gouge, to secure better drainage. The tubular sequestrum (still showing the circular opening made by the trephine, and the upward enlargement of this opening made by the gouge) was removed about four months later. It might well have been removed sooner, before the involucrum had become sclerotic; but the surgeon in charge of the patient delayed operation because the X-ray indicated that the sequestrum was not completely detached. This delay left the boy with a bone cavity which was treated by planefaction.

Fig. 9.

Case VI.—Martin T., 27 years of age, subacute osteomyelitis of the upper end of the ulna. (August 13, 1920.)
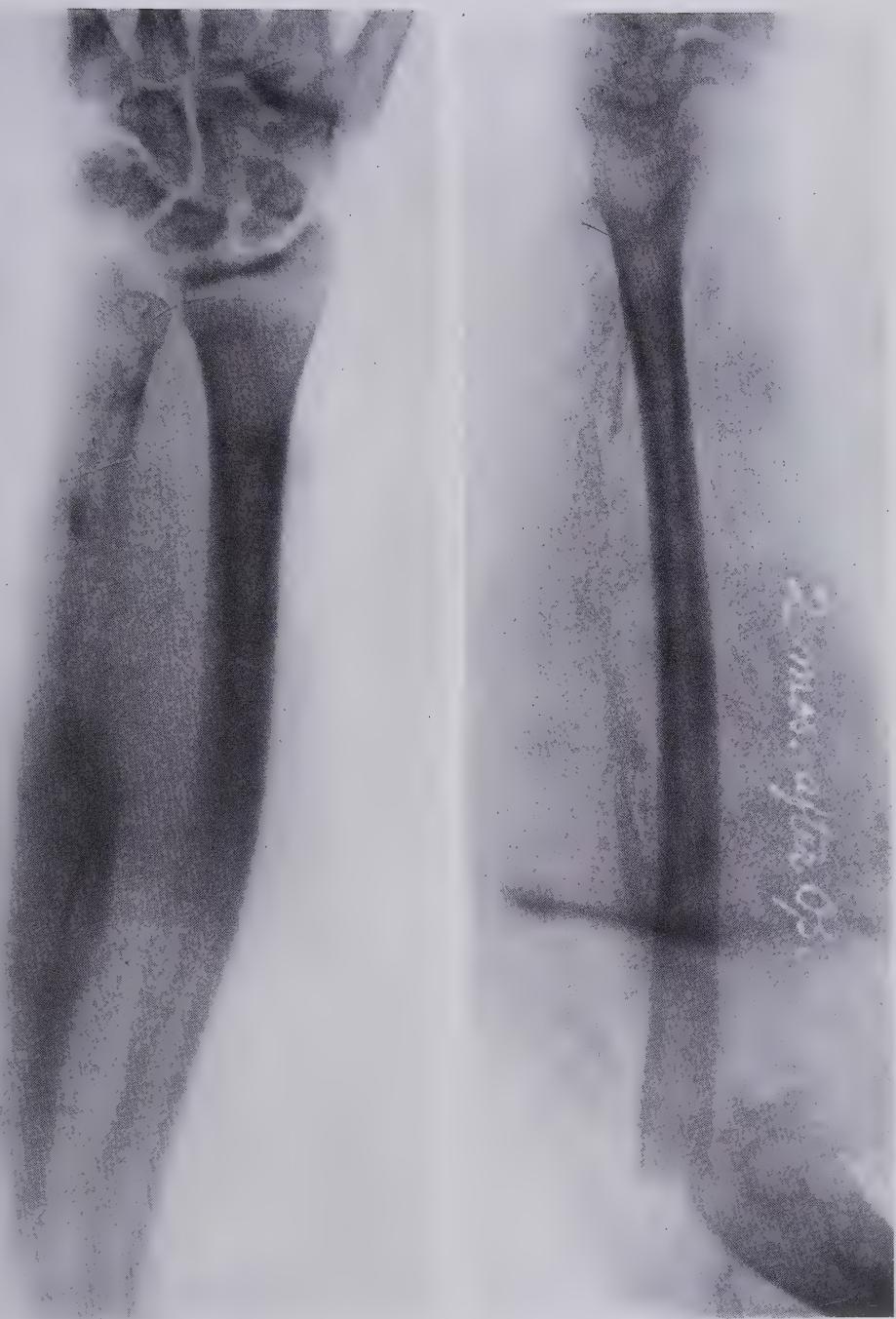
Case VI.—Martin T., two months after second operation, August 20, 1920: Subperiosteal removal of a large sequestrum, while the involucrum still was plastic. As the elbow-joint was full of pus the upper ends of the radius and ulna were removed, to facilitate drainage.

Fig. 10.

FIG. 11.
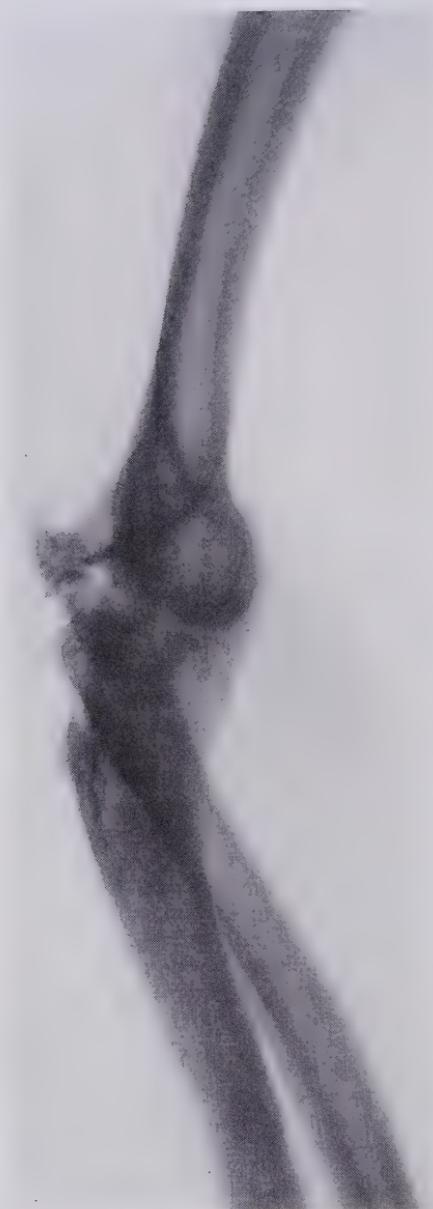
Case VI.—Martin T., sixteen months after the condition shown in Fig. 10. The ulna has now completely regenerated from the plastic involucrum but there is bony ankylosis of the elbow. The soft parts have been entirely healed for over a year.

about nine months from his work; but after working long enough to keep his family through another period of hospitalization, he returned early in 1923, when I excised his elbow-joint, restoring a very useful range of motion (80 to 160 degrees), and with quite sufficient stability and strength for his work as a farmer.

Then we come to the *second stage operation* which is required in practically every case, and is to be done after the proper interval, varying from eight to twelve weeks on the average. Many surgeons, who have no clear idea of the morbid anatomy of the disease in its various stages, are content to subject the patient to numerous and repeated curetments during this stage. Such treatment is not only utterly futile, it is positively harmful. It destroys the regenerating marrow, usually fails to secure removal of sequestra, and invariably leaves the bone cavity unhealed. The operation suited to the second stage of the disease, unlike that appropriate to the first, is not an emergency measure to save the patient's life; it is a methodical and sometimes tedious undertaking, and if incomplete and lacking in thoroughness very likely will require to be repeated at a later date. It is best done under Esmarch anæmia; by this we understand first rendering the limb bloodless, and then keeping it so during the course of the operation. In almost all cases it is sufficient to empty the limb of blood, to have it held as nearly vertical as possible for a period of about three minutes. It is best to time this interval by the clock, for the assistant holding the limb in the air will think three minutes have elapsed before the expiration even of one minute. Then before lowering the limb the Esmarch band, of broad, thick, flat rubber, is carefully and firmly adjusted around the limb well above the seat of the operation, taking care not to place it where it may compress any nerve-trunk directly against bone, as, for instance, the peroneal nerve against the neck of the fibula, the ulnar above the elbow, or the musculospiral at the middle of the arm. This band may then remain in place until the operation is completed and the wound dressed—a period rarely exceeding an hour. The anæmic state of the limb makes more rapid operating possible, and the absence of hemorrhage greatly aids the patient's rapid convalescence. The operation may consist merely in the removal of cortical sequestra which may be found lying loose on the surface of the bone, or may be beneath a well-formed involucrum. At this stage the involucrum is composed of comparatively soft bone, which is still plastic and can be reflected over the

underlying sequestra without destruction of the periosteal covering of the involucrum. If a tubular sequestrum is found, of course it will be necessary to open the involucrum more widely to secure its removal. In very few cases is it desirable to wait for removal of the sequestra until the X-ray shows that they are totally detached, because by this time the involucrum will have become sclerotic, and after the removal of the sequestra there will remain a bone cavity which will not be spontaneously filled up by newly formed bone. If this second operation has been postponed until the involucrum has become sclerotic, then it may be desirable at this time, as soon as the sequestrum has been removed, to combine this operation of sequestrotomy with one which may be called *planefaction* of the bone. This consists of cutting off the roof and the sides of the cavity in which the sequestrum lay until only a posterior shell of bone remains, thus permitting the soft parts to grow over the bone at the sides and aid in causing obliteration of the bone cavity.

CASE VII.—*Bone Cavity Remaining after Évidement of Tibia, Cured by Plane-faction.*—Martin H....., three years of age, was admitted to the Episcopal Hospital, August 30, 1921, with acute osteomyelitis of the upper end of the right tibia. I made an incision over the subcutaneous surface of the bone, and found the subcutaneous tissues œdematous and creamy pus beneath the periosteum. This pus came from the posterior surface of the tibia, having detached the periosteum around its entire circumference without perforating it. On the surface of the cortex there had already formed a little soft new bone. The cortex was opened with gouge, and the marrow spaces were found full of pus. The cortex was guttered from the epiphyseal line downward until normal marrow was reached; this was about the middle of the shaft. Through the opened bone a perforation of macroscopic size was seen in the posterior portion of the cortex. One iodoform gauze wick was placed in the bone opening, and another posterior to the tibia beneath the periosteum.

Convalescence was uneventful, and when I went off duty, November 1, 1921, it was almost time to consider the advisability of a secondary operation for the removal of sequestra (Fig. 12). I did not see the child again professionally, owing to a rotating service in the children's ward, until November 1, 1922, about fourteen months after the onset of the disease. I found his leg in just about the same condition as that in which I had left it a year before, with the notable exception that the involucrum was now thoroughly sclerotic and incapable of obliterating the cavity even if the contained sequestra had been removed. I found that during the year I had been off duty the sinuses in the boy's leg and the cloacæ in his involucrum had been subjected three or four times to curetment under an anæsthetic. Such methods are utterly ineffectual in the treatment of bone cavities such as these; they might be cureted from now until Doomsday, and they would never heal. What is required is either the removal of the roof and

Fig. 12.

Case VII.—Martin H., 3 years of age, December 16, 1921; 4½ months after *evidement* for acute osteomyelitis of tibia. The cavity is surrounded by still moderately plastic involucrum. The proper time for operation was allowed to pass by, and when he came under my care in November, 1922, the cavity was unchanged, but the involucrum had become sclerosed.

Fig. 13.
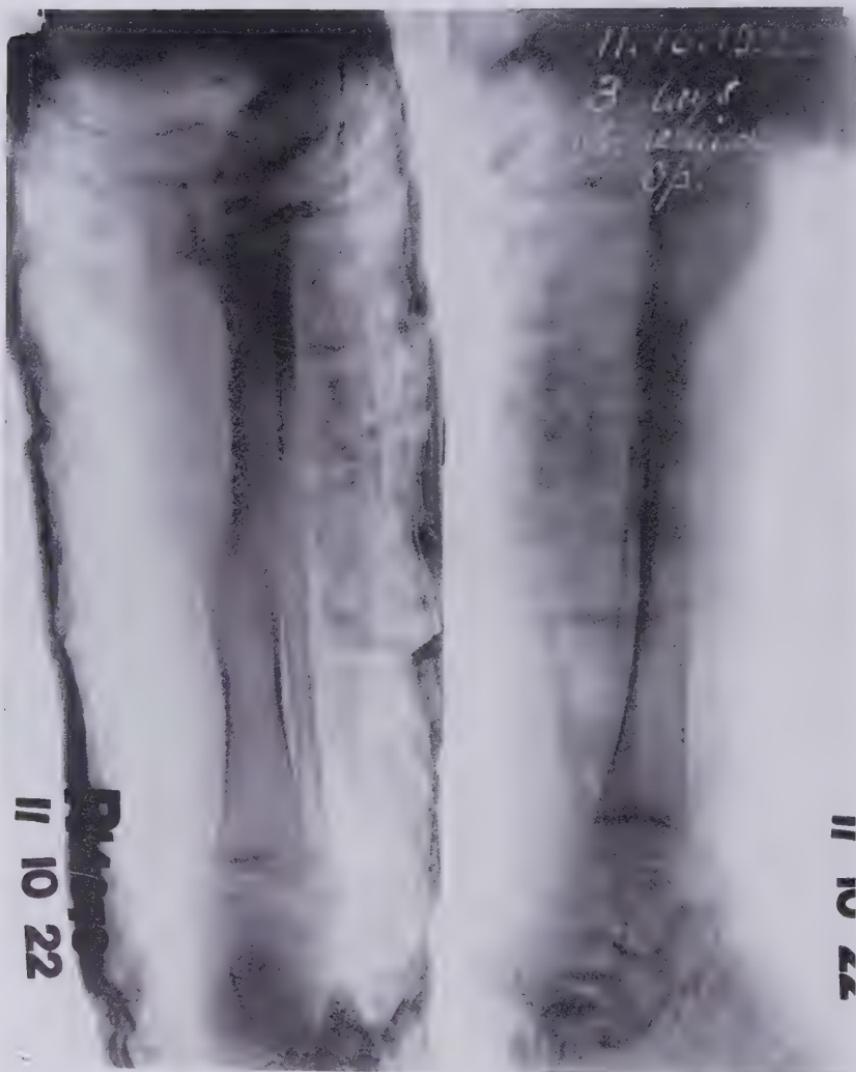
Case VII.—Martin H., November 10, 1922, three days after planefaction of the cavity in the upper end of the tibia. This operation could have been done to better advantage about a year earlier.

FIG. 14.

Case VII.—Martin H., January 4, 1923, two months after planefaction. The soft parts are entirely healed for the first time since the onset of the disease seventeen months before. They remain healed a year later.

Fig. 15.

William C., 50 years of age: Pathological fracture of humerus as first sign of osteomyelitis. Following a neglected infection of the hand he developed septicæmia and was in bed many weeks. During his convalescence he helped himself in and out of bed by resting much of his weight on his elbow. A low fever continued. One day he complained of pain in the arm, and the humerus was found fractured above its middle. The overlying soft parts were normal up to this time. Immediately after the fracture the temperature became normal, but a parosteal abscess formed in the soft parts. In spite of prompt guttering of the humerus the patient's condition steadily grew worse, and amputation failed to prevent death, three months after the onset of the infection of the finger.

sides of the cavity (planefaction) to permit the soft parts to grow over the bone and obliterate the cavity, or, in rare instances, where planefaction is inadvisable for one reason or another, *plombage* may be tried after sterilizing the cavity as effectually as possible. I will speak of this method presently.

November 7, 1922, I proceeded to the operation, with an Esmarch band above the knee. Two of the sinuses admitted a probe into the bone cavity; the other sinuses appeared superficial. An S-shaped incision was made through the old scar, disregarding the sinuses. (A straight incision is more difficult to close over a gap than one which is S- or even bayonet-shaped.) The very densely adherent scar and what remained of the periosteum were reflected from the anterior two-thirds of the bone from its condyles to the lower third of the shaft. One abscess cavity was found within the bone in the lower half of this area, and another in the upper half, each containing sequestra. A third sinus on the lateral surface of the leg was now found to lead into a third abscess in the head of the tibia, extending almost to the epiphyseal cartilage. The entire anterior and median surfaces of the tibia were cut away from the epiphyseal cartilage down to the lower end of the thickened shaft where normal fatty marrow was encountered (Fig. 13). All the chips of bone were carefully removed. Failure to remove them delays healing of the wound, as each chip will form a sequestrum. The wound was then partly filled with 10 per cent. formalin solution, and the muscles and skin were drawn together over the bone with deep interrupted mattress-sutures of silkworm-gut, nearly obliterating the cavity. No drainage was provided other than such as might take place between the sutures.

This unfortunate little boy passed again from my care about three weeks after operation, when he developed measles; but after about three weeks in isolation he returned to my care in January, 1923; his wound was now entirely healed with the exception of two superficial sinuses at the upper end of the incision. On January 11th, I extracted from one sinus a minute sequestrum and from the other an overlooked suture of silkworm-gut. Six days later (January 17th) the entire incision was solidly healed and the boy was soon returned to his home after living in the hospital for a period of seventeen months (Fig. 14). He has had no further trouble with his leg since this radical operation, now more than a year ago.

This operation, which I have called "planefaction," and which has been called by the Boston surgeons *saucerization,* is by no means a new operation; for the older surgeons who began their practice in the War of the Rebellion, and who had all through their professional life many cases of necrosis to treat, knew its advantages well, and I remember being taught myself as a student how important it was to cut off not only the roof but the sides of the bone cavity so as to provide for its obliteration, and I saw this operation performed many times by my father. Whether or not the soft parts can be closed completely over the bone at this operation, they nearly invariably will grow over it subsequently, and the disease will be then radically cured.

I think it well to warn you, however, of two important points:

One is that some sequestra will heal in place and give no further trouble; the other is that pathologic fracture sometimes occurs when too much of the involucrum is removed. Frequently in military surgery I have seen even large sequestra shown by the X-ray in limbs which had been firmly healed and without symptoms for months; and it certainly would be the height of folly to attempt their removal under such circumstances. Pathologic fracture is a serious complication in osteomyelitis, and not always avoidable. I have seen it as the first indication of a " quiet " osteomyelitis of the humerus (Fig. 15); but it is more usual during convalescence after a second-stage operation (Fig. 24). Often it is a separation of the epiphysis rather than a fracture through the shaft; and I am inclined to believe the former is the less serious because occurring in the expanded cancellous end of the bone where repair of the fracture is more certain.

Another operation which is sometimes done at this second stage of osteomyelitis was introduced about twenty-five years ago and advocated by Doctor Nichols, of Boston. It consists in total excision of the diaphysis of the bone, of course preserving the plastic periosteum. When this operation is done at the *proper stage* of the disease it is possible that the shaft will be reproduced from the still plastic bone which lies beneath the periosteum (Fig. 16), but in a great many cases the operation appears to be done at the wrong stage, either before this new bone has formed, or after it has lost its power of regeneration; then the shaft fails to be regenerated, leaving a deformed, frail, or helpless limb (Fig. 17). I have employed the operation in the tibia only once, when it was a failure, and it was subsequently necessary to operate again to stabilize the limb. In the fibula, on the other hand, it may be employed with a much greater chance of success because even if the fibula does not re-form completely it will re-form to a sufficient extent to serve the functions which are required of this slight bone (Figs. 18, 19 and 20). In the femur and the humerus the operation is very rarely, if ever, advisable. It is better in such cases to trust to extraction of the sequestra and the planefaction of the cavity which is left. There are, however, certain cases of chronic infiltrating osteomyelitis without sequestrum formation in which nothing short of subperiosteal resection will certainly cure the patient; but in such cases it may be better to have an unhealed

Fig. 16.

Flail limb resulting from subperiosteal resection of the ulna for acute osteomyelitis.

FIG. 17.

FIG. 18.

Flail limb resulting from subperiosteal resection of the tibia for acute osteomyelitis.

William H., 10 years. Subacute osteomyelitis of fibula. October 20, 1913.

FIG. 19.

FIG. 29.

William H., October 29, 1913.
A few days after subperiosteal re-
section of the fibula.
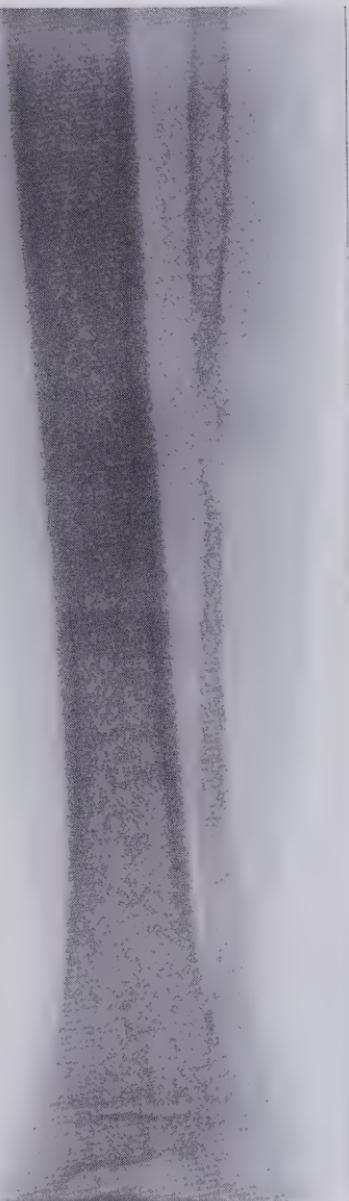
William H., August 31, 1914. Ten months
after subperiosteal resection of the fibula, showing
nearly complete regeneration.

Fig. 21.

Eugene S., 13 years. Markoe's abscess of tibia. May, 1915, injury to tibia; July, 1915, pain; August, 1915, abscess incised. In December, 1915, a sinus persisted, from which small spicules of bone had been discharging. X-ray showed a cavity. At operation, December 8, 1915, the cavity was exposed, sterilized, and filled with iodoform bone wax. In November, 1916, the incision was firmly healed, though it had remained moist at one spot until the preceding June.

chronic osteomyelitis, with a sinus which most of the time is scabbed and only rarely discharges, than to do so radical an operation as to risk the patient's life or the usefulness of his limb.

There is still another way in which a bone cavity may be treated after the removal of the sequestrum without complete planefaction. This is an operation known by the French name *plombage,* and consists in filling the cavity with some sort of paste which is designed to remain there and to be gradually absorbed as it is replaced by the proliferating bone growing in from the walls of the cavity. For this purpose I have found nothing so satisfactory as the iodoform bone-wax of Mosetig-Moorhof.[1]

This is composed of iodoform, 60 parts; spermaceti and oil of sesame, each 40 parts. These ingredients are mixed in a sterile pan, on a water-bath, being heated slowly up to 80° C., and the temperature of the mixture is then kept at 80° C. for fifteen minutes, being constantly stirred. The fluid mass is then removed from the water-bath, and is allowed to cool while being constantly stirred. This long-continued stirring is considered extremely important in order to secure exact emulsification of the iodoform. Before being used the solidified mass is warmed up to 60° C. on a water-bath, being constantly stirred until entirely fluid. When the cavity has been sterilized, first by mechanical, and then by chemical means, the wax is poured into the cavity flush with the level of the soft parts, which are then closed over it without drainage. The best results follow when the cavity can be thoroughly sterilized. Mosetig-Moorhof himself employed a blast of hot air to seal and sterilize the cavity; but it is difficult to secure such a blast in the ordinary operating room, and after making various attempts and not succeeding in getting the blast hotter than 100° C., and being told by bacteriologists that air delivered at that temperature in a rapid blast has not time to sterilize itself, still less to sterilize the cavity, I have been content of late years to swab the cavity with formalin solution (5 to 10 per cent.) before pouring in the wax. If there is very little infection and if this has been largely overcome by mechanical or chemical means at the time of the second operation, the wax may remain in place and the soft parts heal over it (Fig. 21). Then in

[1] *Annals of Surgery,* 1917, Vol. lxv, 2, 227.

the course of weeks or months it will be gradually absorbed and successive X-rays will show the cavity growing smaller and smaller concentrically. If, on the other hand, the infection is more virulent, or if, as is frequently the case, there is much scar tissue in the soft parts and sloughs form along the edges of the incision after they have been sutured over the wax then the incision may reopen in part or in its entirety, leaving the wax exposed in the wound. Then I am in the habit of letting it stay in the wound until it is pushed out by the crowding of the regenerating bone and the cicatrization and contraction of the soft parts. It is less disturbing to the patient each time the wound is dressed merely to have the surrounding skin cleansed and a dry dressing applied over the wax than it is to have a large granulating surface exposed each time the surgeon dresses the wound.

During the convalescence of the patient from a primary operation and throughout the course of the second stage of the disease it is very important to pay attention to the general condition as well as to the diseased limb. The patients are very sick and septic and they require careful nursing, prevention of bed-sores, and constant watchfulness on the part of the surgeon to discover new foci of involvement in the soft parts or in the bones. Then it is important, when the disease involves any joint and especially the upper end of the femur, to guard against the occurrence of dislocation which is a frequent complication. It is best to put a Buck extension on these patients at the time of the first operation and to maintain the limb in abduction and full extension until convalescence is well established. If the joint becomes secondarily invaded, of course, it will be necessary to open it and secure dependent drainage, usually at the same time removing the sequestrated head of the bone; in other words, doing what practically amounts to an excision of the joint. At joints other than the hip, although a complete dislocation is rare, a subluxation or a contracture with disabling deformity is by no means unusual, and to prevent this it is necessary to keep the joint properly extended; moreover, such efficient splinting assists greatly in the repair of the bone and of the soft parts.

So far I have said nothing about *bone abscesses* as distinct from diffuse osteomyelitis. The chronic bone abscess which is known by the name of Brodie because well described by him, was nevertheless

FIG. 22.

Vincent B., 20 years. Brodie's abscess in lower end of left femur, giving symptoms only for few weeks. Had operations on lower ends of both tibiæ several years ago for osteomyelitis; these wounds have been healed and the disease apparently cured for many months. But within a few months a sinus opened spontaneously over the great trochanter of the left femur; and when this scabbed and ceased to discharge, he developed pain in the lower end of the same bone (bipolar osteomyelitis of Ollier). Drilling the abscess (November 28, 1923) promptly relieved his pain, and the soft parts healed in a few weeks. Nevertheless the patient is not cured, and the disease probably will recur here or elsewhere.

Russell C., 16 years. January 22, 1923, large Brodie's abscess in lower end of femur. Treated by *evidement* and *plombage*. Incision later reopened for persisting infection. Planefaction in August, 1923. (See Fig. 23b, for different viewpoint for the röntgenogram.)

Fig. 23*b*.

Same patient as in Fig. 23*a*, the röntgenogram being taken from a different viewpoint.

FIG. 24.

Russell C., 16 years, October 29, 1923. A pathological fracture occurred while walking in the street five days after leaving the hospital, with only a small sinus, barely moist, and wearing a brace.

known to surgeons long before his day, and was efficiently treated. It arises in the same way that an acute osteomyelitis does, but presumably the infection is much less severe, or the resisting powers of the patient much greater, because the history usually shows that the patient complains of disability in the limb for weeks or months, sometimes for years, before coming to the surgeon, and examination shows very little except pain and tenderness in the bone end to indicate that there is any disease within. The bone seldom is notably thickened or deformed, and if it were not for the X-rays, which serve to show us the cavity within the bone, we would have to depend upon the persistent localized pain and tenderness for making the diagnosis. There is an abscess described by Doctor Markoe, of New York (who wrote an interesting book on " Diseases of the Bones," published in 1872), and known to surgeons as Markoe's abscess, or a " chronic sinuous abscess of bone." As far as I can understand Doctor Markoe's description he seemed to think that the disease arose on the surface of the bone and afterward penetrated to its interior, but those cases which I have seen and which corresponded with his descriptions seem to me to have been rather cases of Brodie's abscess which had discharged themselves spontaneously through the cortex and overlying soft parts, and so formed the chronic abscess in the interior of the bone communicating through a sinuous tract with the surface of the limb, which is what Markoe described. A small indolent Brodie abscess may well be treated by simply drilling the overlying bone and allowing the pus to discharge (Fig. 22); because if the process has not been of long duration, or the grade of infection too severe, the surrounding bone will not yet have lost its powers of proliferation, and simple drainage of the abscess may bring about an obliteration of the cavity. That, you may recall, is the method which has recently been advocated by Doctor Brickner, of New York; but in most cases of Brodie abscess the cavity is surrounded by sclerosed bone, and it is manifest that simply draining it will merely convert a Brodie abscess into a Markoe abscess and the disease will continue. Hence something else must be done if the patient is to be cured. One woman came to me with the history that she had had a Markoe abscess discharging intermittently for twenty-four years without causing very great disability, and it was only at the end of this time that she

decided to seek a cure. In cases such as this simple drilling and drainage of the bone abscess will not affect a cure, for the reason I have already stated. Something else must be done. This something else may consist either in plombage, such as I have described for other bone cavities (Figs. 23a, 23b and 24), or, in the more extensive cases, of planefaction by cutting the roof of the abscess off and trimming down its sides flush with the floor of the cavity.

Now you can see when you stop to consider all the various complications and sequelæ which may follow this disease that I was quite right in speaking of it as a terrible affection, a disabling disease which if improperly treated may last the time of the patient's natural life even if it does not shorten his days. There are few diseases of childhood which it is so important to recognize early, and there are few, if any, which bring such satisfaction to the surgeon and to the patient when they are recognized early and treated properly.

Pathology

METASTASIS *

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of the National Board of Medical Examiners

FEW conceptions have prevailed in medicine as long, and with as many varying phases of meaning, as that of metastasis. Perhaps by bringing together a few of the facts concerning the various forms of metastasis, each of which is usually considered separately, we may succeed in finding that they have much in common.

The term metastasis is of Greek derivation from the verb, μετασταω, to transport, and can perhaps best be translated by our words " removal " or " change," but as time has passed the term metastasis has acquired meanings with special associations conforming to the medical beliefs of each period.

In the times of Hippocrates and of Galen the idea of metastasis appeared in association with the terms coction and crisis; coction perhaps being synonymous with pus formation and referring to the preparation of the disease for elimination, crisis signified the elimination of the disease, and metastasis the transfer of the disease from its original site to some other portion of the body. For centuries the thought that disease may end by death, by cure or by metastasis was prevalent. With varying theories of disease the conception of metastasis was applied to suit the theories of the vitalistic school, and to fit the " solidiste " theories. At one time interest in metastasis centred about the transfer of mumps to the testicles, at another to the transfer of suppuration to a distant focus, at another to the transfer of hemorrhage from one site to another, as for example hemoptysis replacing hemorrhoidal bleeding.

In the early days it was believed that body fluids passed freely

through the body tissues and that a new deposit of disease, or metastasis, was due to an obstruction being met. From this viewpoint metastases of milk, of bile and of sweat were possible; serious phenomena could arise from a too sudden suppression of sweat of the feet. Pituitous metastases from the brain were also much discussed.

Translators and commentators of the Hippocratic writings point out this conception of metastasis in several of the aphorisms; in John Redman Coxe's version written in 1846 one reads "Lumbar pains, their fatal metastasis to the præcordia and head."

These older views concerning metastasis continued to prevail until quite recent times. For example in Astruc's book on fever written in 1747 one reads "The milk * * * is very often thrown on other parts, where it creates metastases the most incorrigible and obstinate." On the other hand Goursaud in 1759 won the prize of the Academy of Surgery of Paris with a thesis on metastasis which concerned only metastasis of suppuration. A hundred years later, however, a thesis by Tholozan still classes metastasis with crisis or cure; while Good in 1822 refers to "metastatic dropsy from repelled gout." Apparently metastases of three varieties were recognized in the last century: Mechanical, infectious and diathetic.

While these views continued to be held in the attempt to explain phenomena, many of which still find their explanation to-day in similar theories, attention was also being directed to the metastasis of tumors. In the early years of the eighteenth century Le Dran, who lived from 1685 to 1770, conceived that if a drop of cancer lymph passed the adjacent nodes it contaminated the entire system. It was the discovery of the lymphatic apparatus that had discouraged the older view that fluids passed freely throughout the body. In 1829, Recamier, who is known to us not only by his book, "Researches on the Treatment of Cancer," but by an interesting life by Triaire, studied the infiltration of cancer into the surrounding tissues, observed the destruction of veins and applied the term metastases to nodules in the brain in a case of mammary cancer. In discussing these secondary deposits he writes that "it leads one to admit cancerous metastasis." This view of the spread of cancer by the escape of free cancer cells into the venous blood-stream was compared by Hannover to the production of secondary suppurative foci in pyæmia

by the metastasis of pus cells. Later Langenback, Follin and Velpeau demonstrated the occurrence of tumor nodules in the lungs of dogs receiving intravenous injections of tumor emulsion.

It remained, however, for Waldeyer to show that secondary growths were not all the result of metastasis by free cells but might result from a continuous growth of the tumor along the blood or lymph-vessel.

In 1855 Virchow described under the name " Metastatic Calcification " the occurrence in conditions with much destruction of bone, of deposits of lime salts in various organs particularly the lungs and stomach, and to a lesser degree in the kidneys. This use of the term metastasis was amplified by Virchow three years later in his famous " Cellular Pathology." Lecture X in this work is entitled " Metastatical Dyscrasiæ " and in this while admitting that embolism constitutes the most tangible and gross form of metastasis he protests against the identity of embolism and metastasis and points out their lack of similarity. It is evident throughout that he was influenced by the older views of metastasis. Under this term he is quite willing to include the transfer and deposition of silver salts in the tissues, the deposition of gouty tophi, and the deposition of the so-called calcareous metastases already referred to. Embolism on the other hand he pictures as the transference of some gross particle as for example a broken-off bit of vegetation from a diseased heart valve.

Virchow was led astray in applying these thoughts to the propagation of malignant tumors. He appreciated the extension of a tumor along a lymphatic channel or along a vein, but the locations of secondary metastatic growths differed so greatly from the sites of deposit of emboli that he concluded that the metastasis probably could not result from the deposition of detached free cancer cells but that, to quote his own words, " the transference takes place by means of certain fluids, and that these possess the power of producing an infection which disposes different parts to a reproduction of a mass of the same nature as the one which originally existed." He draws an analogy to smallpox and then continues: " As the salts of silver do not deposit themselves in the lungs, but pass through them to be precipitated only when they reach the kidneys or the skin, so an ichorous juice may pass from a cancerous tumor through the

lungs without producing any change in them, and yet at a more remote point, as for example in the bones of a far distant part, excite changes of a malignant nature."

These views, supported by the weight of Virchow's fame, led to great confusion in this field. For example in 1880 we find a French thesis by Gils with the title "Letters to My Friend, Dr. G. Pons, on the Non-existence of Metastasis," advocating the view that cancer spreads by growth or by embolism, that embolism and metastasis are not the same, and that metastasis in the older sense did not exist at all.

Many injection experiments have been performed in the hope of learning something about embolism and metastasis. Probably the first attempt was that made by Cruveilhier in 1826 by injecting globules of mercury into the blood-stream in lower animals. He observed that abscesses formed wherever the globules lodged in the vessels. Of late years various forms of particular matter and bacteria have been employed. The somewhat unexpected localization of such particular matter as manganese, which was used by Drinker, or of tubercle bacilli as used by Foot, is in large part to be attributed to the activities of the phagocytic endothelium lining the capillaries of the lungs, liver and spleen. The differences in localization in different animals can thus be explained, and also the remarkable influence which splenectomy has upon the distribution of lesions following the injection of tubercle bacilli.

The size of the particle and the species of the animal employed influence the distribution of manganese particles injected into the circulation. In the cat the larger particles tend to lodge in the lungs and the smaller ones in the liver, although the largest particles did not approach in size the diameter of the mammalian lung capillaries. In the rabbit the liver received almost all the particles. Drinker does not believe that these differences are to be explained on capillary blockage or on differences in blood flow to the various organs, but on the varying activity and distribution of the vascular endothelium.

So-called metastatic abscesses are distributed in some instances clearly as a matter of embolic blockage of end arteries or of finer vessels and capillaries. Wherever an infarct can occur there a metastatic abscess may develop. This is particularly well exemplified by the multiple secondary abscesses which develop in the liver from

a portal thrombophlebitis. In such instances the embolus is probably not a single free bacterium but either a clump of bacteria or a bit of the thrombus with adherent bacteria. On the other hand when the bacteria are scattered free throughout the circulation, the distribution of secondary deposits is not identical with that of emboli; as Adami writes, "secondary abscesses are not indifferently distributed over the whole body." Other factors must enter into this distribution, factors such as the relative amount of blood flow to each organ, the rapidity or sluggishness of the flow through the various capillary beds. Cheesman and Meltzer found that they could cause bacteria circulating in the blood to settle in any place they might select by mechanically injuring the tissues of the part. Almost every writer on pyæmia and also the authors of textbooks on pathology describe and recognize the factor of tissue predilection in the localization of secondary and of tertiary abscesses, as some name those abscesses which they believe are the results of a second propagation of infectious material. Certain organs which, because of their rich blood-supply and fine capillary beds, would seem to be ideally suited to be the seat of multiple foci may escape wholly or in part; not because the bacteria have not been brought to them by the blood-stream, but because having reached the organ they there fail to lodge, survive, multiply and excite tissue reaction. There must, it would seem, be at least two aspects of this problem, the needs and requirements of the invader on the one hand, and the various conditions, chemical, structural, thermic, immunological, presented by each different tissue.

Many bacteria display a very definite selective action in the points of their localization in the body. These are too well known to need repetition here. What determines them is not known; there is some little evidence to suggest that the frequency with which the gonococcus finds lodgement on the valves of the right side of the heart depends upon the higher carbon dioxide content of the venous blood, but this is far from proven. In other instances it may be the oxygen content of a tissue which determines its possible flora. When several tissues are invaded by an organism it is possible that in one instance it is the result of the interception of an embolus, while in the second the metastatic lesion is determined by some tissue predilection perhaps chemical in nature or immunological. It is

possible that in the future the mystery of many immunological reactions will be reduced to chemical or physical terms. Rosenow's claims of a greater selectiveness displayed by certain strains of bacteria enter into the problem merely as a matter of degree without really making it any more difficult. Nor do the so-called metastatic lesions from foci of infection, as for example an iritis secondary or, as Irons prefers still to say to-day, metastatic, to a tonsillar infection for example, open any new lines of argument.

In mumps the etiologic agent is undoubtedly a filterable virus and it seems reasonable to suppose that it is this virus which (extending beyond its primary site in the parotid) may secondarily involve the testicle, ovary, breast, or pancreas. To explain these localizations of reaction one must assume for them some common basis—chemical, structural, thermic, or what not. Certainly it is not accidental, nor can the localization of a filterable virus be thought of as being influenced by blood flow and capillary obstruction as is the distribution of emboli. The tissues affected by the virus of mumps have in a general way, it is true, certain resemblances and although we cannot as yet interpret it, the explanation must eventually be found in these tissue likenesses.

We see that metastasis of infection is still poorly understood to-day; that at times the clumped bacteria act as emboli; but that in other instances some specific selectiveness is displayed by bacteria or by tissues, analogous to that seen in the metastasis of filterable viruses and of inorganic particles.

Metastatic calcification was described by Virchow and the basis of his report was a case which may well have been one of multiple metastatic carcinomatous tumors of the bones. It is in conditions with much destruction of bone that these deposits of calcium are most frequently found. Normally the amount of calcium in the blood is too slight to be influenced by local changes in the reaction of the blood, but when the calcium content of the blood rises above normal it is more readily thrown out of the blood in local deposits. The sites of the deposits are particularly the lungs, stomach and kidneys, and the theory has been advanced, and is given some weight by Wells, that in these organs the excretion of acid may leave the tissue fluids

correspondingly alkaline with a resulting lessening of the solubility of the calcium salts.

Metastatic calcification in these areas has been reported not only in cases with bone destruction but also in nephritis in which it is supposed there was a retention of calcium, and occasionally it has been found in the absence of any discoverable etiology. Metastatic calcification must, it seems safe to say, be purely a chemical matter and the sites of localization must be determined by local chemical states favoring the deposition at that point of the calcium.

When we consider tumor metastasis we find that many of the factors already discussed enter in, and in fact that marked similarities exist between infectious metastasis and the metastasis of tumors. There are, however, fundamental differences; the two processes are far from being identical.

The formation of metastases is a characteristic of some tumors and not of others; Virchow described it as occurring in proportion to the "abundance of parenchymatous juices in the pathological formation." Others have attempted to relate metastasis to anaplasia or the property of cells to revert to a more primitive type, and while these two often go hand in hand yet this is not always true. The malignancy of a tumor is usually judged on its degree of anaplasia, its power to infiltrate and its power to metastasize, but a distinctly anaplastic tumor may give no metastasis, while tumors with little histological evidence of anaplasia may give metastasis. Spindle-cell sarcoma of the dura mater, the epulis, many sarcomata and cancers of the ovary, uterus and mediastinum, are tumors which might be expected to metastasize and which do not do so. On the other hand anatomically mature, so-called benign tumors, such as the fibroma, the myxoma, the lipoma, the glioma of the retina, and typical thyroid tumors are listed by various writers as occasionally leading to secondary growths. Apparently even normal tissue cells transported to a distance may multiply to produce what may well be classed as a neoplastic growth; in a sense a tumor metastasis from a non-tumorous origin. This possibility we must admit unless we deny Simpson's beautiful work on the formation of intestinal adenomyoma by transplantation of endometrial cells from uterus to ovary and then by rupture of a so-called chocolate cyst, to the peritoneal space

where they implant themselves on the intestinal wall to form adeno-myomas, some of which apparently show true invasive malignancy.

Many factors must enter into this matter of the formation of metastasis by tumors. The richness of the blood-supply and lymph-supply of the tumor, the tendency of the tumor to penetrate and invade one or other sets of vessels, and the frequency with which its cells are freed into the circulation are obviously important. Pressure on the tumor, especially intermittent pressure, must sometimes assist in the escape of tumor cells into the blood or lymph-stream.

The size of the tumor cells must influence the readiness with which they will be transported by blood or lymph but more important is the question of their ability to resist the destructive action of the fluids and tissues of the body. Unless the liberated tumor cells can lodge and can multiply, no metastasis will occur. Tumors frequently give off cells which lodge in the lung capillaries or elsewhere but which never go on to the formation of secondary growths. Such cells may be promptly destroyed or may remain quiescent, hindered from proliferating by antagonism of the tissue or as Symmers puts it " by equilibrium of function in the cell itself." Such cell deposits do not fulfil the conception of metastasis which must include not only deposit but subsequent growth of the misplaced tumor cells with replacement of physiological tissue. As Armstrong and Oertel have written: " The problem of tumor metastasis is not to be found in the transport and arrest of cells but in their growth to a tumor tissue."

Such apparently quiescent deposits of tumor cells are undoubtedly potential metastases, and may, even after years of latency, commence to multiply when the conditions which have until then restrained them are altered. This may be the explanation of the appearance of metastases long after the removal of a primary tumor, as for example melanotic sarcoma of the liver twenty-one years after the operative excision of the eye.

Apparent metastasis may on careful examination be found to be the result of extension or permeation. Heidenhain in 1889 drew attention to such direct extension of breast cancer along lymphatic channels and Handley has claimed that in mammary carcinoma apparent metastases in the abdomen were the result of direct growth

of the tumor along lymphatics. In fact Handley in his permeation theory tries to explain all secondary cancer growths as due to extension rather than to embolism or metastasis of tumor cells. A similar view is held by Erwin F. Smith concerning the small secondary tumors which develop near the mother growth in crown gall. These appear to be true metastases not connected with the mother growth by any strand of tumor tissue. Smith, however, believes that they are due to the escape of parasites from cells crushed in the growth of the mother tumor. He prefers for these the term pseudometastases and compares his views with those of Krompecher and of Petersen who found small, apparently independent, tumors in the vicinity of the mother carcinoma in human cases.

The mass of evidence, however, proves that tumor cells, either singly or in groups, may be carried by the blood or lymph circulation and deposited at a distance. They travel as a rule with the current, but Oertel and others admit that sometimes by their own amœboid motion the cells may make their way against the current, producing " retrograde metastasis." This occurs in the lymph channels rather than in the blood-stream, and the example quoted by Adami and others is that of the metastasis from cancer of the breast to the head of the humerus of the same side. Difference of pressures at the junction of the thoracic duct with the jugular vein with a resulting reflux of cancer cells into neighboring glands was the theory advanced by Belin in a Paris thesis of 1888 to explain the frequency of metastasis of visceral cancer to the left supraclavicular lymph-node. Somewhat similarly the metastasis of kidney tumors to the liver has been attributed to the negative pressure in the inferior vena cava causing tumor cells actually to be drawn back from the right auricle.

The anatomical arrangement of the veins and lymphatics is often of the utmost importance in determining the distribution of secondary growths. This is well illustrated by Frew's studies on the adrenal sarcoma of infancy. From the right adrenal the secondary growths involve the surface of the liver, the lungs and the right cervical nodes often with a resulting right-sided exophthalmos. The extension from the left adrenal is to the regional nodes both downward along the iliacs and upward to the liver, through the posterior mediastinum, along the intercostal lymphatics and through the deep cervical chain

along the carotid artery to the base of the skull. From the left side the common sites of secondary growths are in the ribs and cranium, from the right in the liver, lungs and right cervical nodes.

Metastasis may also arise as a result of the transfer of tumor cells by apposition, as for example from cancer of the breast to the apposed skin of the arm, or by transplantation of free tumor cells in the peritoneal and other serous spaces, as for example in the peritoneum following a rupture of a cystic ovarian papilloma or carcinoma. One must, however, be careful to rule out lymph channel metastases in such cases.

Localization of neoplastic metastases is influenced by many of the factors mentioned in discussing other varieties of metastasis, for example, such mechanical factors as the stoppage of cells in the first capillary bed, certainly play a part. But the view is held by many writers that if only a few tumor cells enter the circulation they will only succeed in forming metastases in favorable tissue soil even though this be at a distance, but if a sufficient number of cells escape from the tumor then metastases will appear both in the favorable tissues wherever located and also in the organs or tissues intercepting mechanically a large number of the cells.

What constitutes a favorable tissue? In what does tissue antagonism or predilection consist? Certain it is that tumors show a greater tendency to form metastases on certain soils than on others, often on tissues resembling those in which the growth originated or at least having a biogenetic relationship. It is claimed there is a tendency to metastasize to tissues derived from the same layer of the blastoderm. Lymphosarcoma tends to settle in lymphoid tissues; carcinoma of glandular organs is likely to give metastases to other glandular organs of the same derivation. A favorable tissue for metastasis is perhaps one which does not resist or destroy the transported cells as does an unfavorable tissue. But an unfavorable tissue may lose its power of resistance through trauma or perhaps as a result of toxic products of the metabolism of the primary growth.

It has been suggested that neighboring lymph glands successfully destroy tumor cells until inflammatory or toxic products from the tumor reduce the gland's resistance. Cohnheim stated: " Only when and where tissues are lowered in their physiological metabolism by

age, atrophy and inflammation will metastases be possible." An overwhelming dose of cells will, however, overcome the resistance of an otherwise unfavorable tissue. In a study of ninety-six consecutive cases of metastasizing tumors Armstrong and Oertel could define but two factors determining the localization of metastases: The quantity and quality of the tumor cells. When but a few cells entered the stream qualitative selection ensued, when many entered a quantitative overwhelming of the body resulted.

Such factors help to explain the distribution of metastases but the matter is far from simple and many still inexplicable distributions occur.

Virchow was the first to point out that tissues which frequently give rise to primary tumors seldom are the site of metastasis, and conversely that tissues frequently receiving metastases are seldom the site of origin of primary growths. This view has been expressed repeatedly in the literature and recently Symmers has supported it, but Ewing is not impressed with its importance.

Symmers's statistics show that primary growths occurred most frequently in the stomach, œsophagus, large intestine and urinary bladder and the incidence of metastasis to each of these tissues in this series was 1 per cent. or less. The same thing applies to the breast and prostate although Symmers's figures do not make this evident. On the other hand the tissues showing the highest incidence of metastasis are the lymph-nodes, liver, lungs and pleura, and the bone-marrow and bones. None of these is the frequent site of primary growths. Finally, as Symmers says, there is a third group of organs which are neither the frequent seat of primary tumor growth nor of metastatic deposits; this group includes the spleen, heart and skeletal muscle, kidney and thyroid.

For some of these facts an explanation can be advanced, for others no satisfactory hypothesis can be presented. If one attempts to base an explanation of the distribution of metastases upon mechanical and circulatory factors one finds difficulty in explaining the relatively low incidence of metastasis to the spleen and kidney since the mechanical arrangement of these tissues would seem to render them particularly liable to the retention of foreign cells. It is also interesting to remember that the incidence of metastatic abscess is low

in the spleen although not as low in the kidneys. Furthermore, neoplastic metastases to the spleen are almost always small in size and few in number, and usually occur only in cases with widespread metastasis to other organs. Even in carcinomatosis the spleen may escape. It would seem as though one must admit the possibility of the spleen possessing some sort of antagonism to the growth of tumor cells. Exactly what constitutes this relative immunity is not known. The explanation may be found in the newer work on the relation of lymphocytes to tumor immunity. It is also interesting to note that tumors which give metastases to the spleen usually also give them to the bone-marrow.

Metastasis to bone has attracted a great deal of attention. Primary tumors, usually carcinomatous, of the prostate, thyroid, breast, adrenal cortex and uterus give frequent metastasis to bone. These various tissues it would seem have relatively little in common except this well-recognized behavior of their metastases. Von Recklinghausen was the first to point out that since there are no lymphatics in the bone-marrow tumor metastases were probably due to the arrest of malignant emboli in the marrow capillaries. Piney claims that metastasis to bone almost always occurs in the red marrow, as for example in the ribs, vertebræ, skull, sternum and the upper ends of the humerus and femur. Joll's recently published statistics would seem to bear this out. In fifty-three cases with eighty-eight bone metastases the distribution was as follows: Vertebræ 19, 21.6 per cent.; ribs 18, 20.4 per cent.; sternum 13, 14.7 per cent.; femur 13, 14.7 per cent.; skull 9, 10.2 per cent.; and humerus 7, 7.9 per cent. The others were widely scattered.

There are individual types of neoplasm the metastases from which display marked selectiveness in their localization; melanotic tumors from whatever part of the body tend to metastasize to the liver; primary lung cancer is one of a very few tumors which give metastases to muscle; hypernephroma tends to secondarily involve large veins which helps to explain the wide distribution of its late metastases. Certain tissues which appear to be unfavorable for meta-stasis of one type of tumor, prove suitable soil for another. Thus the kidney and the adrenal cortex, which are the site of few meta-stases, both receive a relatively high number of metastases from

sarcomata of various types. The so-called Krukenberg tumor, a coincident carcinoma of the stomach and of the ovaries, is probably primary in the stomach and secondary, perhaps by implantation, in the ovaries.

These few examples are given for the purpose of emphasizing some unexplained aspects of tumor metastasis, and to emphasize further the analogy between tumor and other types of metastasis. There is no reason to believe that the underlying laws are not identical or at least similar in each variety.

One might hope that the study of spontaneous and of transmissible tumors in animals would throw some light on this problem of metastasis. Van Allen and Louise Pearce have studied the mechanism of metastasis following the transmission of a malignant epithelial tumor of the rabbit which when transferred by intratesticular inoculation led to metastasis in 60 per cent. of instances. Within seven days after inoculation both blood and lymph vessels are invaded by the tumor; if metastasis occurs chiefly by the blood-stream the rabbit usually succumbs in four to seven weeks, but if the lymphatics are the chief channels of metastasis the process is slower, ending in death, or recovery, only after several months. By whatever route metastasis takes place the lungs are an important protective barrier to the general body tissues.

Tissue predilection is shown by spontaneous animal tumors and their metastases just as in the case of human neoplasms. For example, in a series of 33,000 mice dying natural deaths Slye found twenty-five primary spontaneous tumors of the kidney, adrenal or urogenital anlage but no secondary tumors of the adrenals and only six of the kidney were discovered. No metastasis to the kidney occurred among 3000 cases of mammary carcinoma and the four secondary carcinoma of the kidney were all from the lung. This resembles the condition found in man. Sarcoma in mice gives metastasis to sites corresponding closely with those observed in human sarcoma, the lung and liver being most often involved, and then the lymph glands. As in human sarcoma the spindle cell variety is much less likely to produce metastases than the round or polymorphous cell types; the fibrosarcoma rarely gives metastasis. The same problems are met, it is seen, in animal tumors and their metastases

as are encountered in dealing with the secondary deposits of human
neoplasms, and no answer has been obtained as yet. It is probable,
however, that the solution of many of our problems in connection
with tumors will eventually be reached through the study of tumors
in animals.

Heredity is a factor which can only faintly be recognized in
connection with the neoplasms of man; in Manichon's family there
were sixty-nine cancer cases, of which fifty-seven occurred in the
stomach, and Warren has reported cancer of the penis in three
successive generations. Wassink and Van Raamsdonk have recently
reviewed this subject. In man the inference seems justified that the
susceptibility to cancer behaves as an inherited recessive character.

In animals, however, the influence of heredity is more readily
appreciated. An analysis of some 4000 primary tumors with 19
per cent. of metastases, occurring in 29,000 mice under complete
biologic control, leads Slye to the conclusion that heredity is a strong
factor in determining not only where the primary tumors shall occur
but also where the secondary tumors shall occur. This seems to
indicate that there is a specificity of tissue type from organ to organ
in a strain which will make these organs react in a given way to a
given type of irritation.

Heredity must then be added to the numerous factors which seem
to influence the production of metastases and their localization.
Anatomical structure, tissue chemistry, tissue predilection, etc., seem
to be the factors the workings of one or more of which are discernible
in each of the various types of metastasis discussed. Both the
pathologist and the clinician would like to be able to explain all
metastases upon a few fundamental laws, but this cannot yet be done.
However, by considering them together many suggestive analogies
present themselves.

A knowledge of the habits of tumors in respect to metastasis
is not only of interest to the pathologist but it is of the greatest
importance to the clinican both in diagnosis and treatment. The
clinician should be familiar with the usual distribution of metastases
from the various common primary growths; he should know what
tumors give metastases and to what tissues. This is of fundamental
importance in determining treatment. On the discovery of a tumor

growth in a given region the clinician should know the probabilities of its being primary or secondary; if primary, the probability of metastasis and its probable sites, if secondary the probable site of the primary growth. Prostatic cancer, undiscoverable on palpation, has been diagnosed from multiple metastases in the pelvic bones; carcinoma of the upper abdomen from a metastatic growth in the left supraclavicular lymph-nodes.

The importance of recognizing a neoplasm as primary or secondary is well exemplified by a tumor of the mediastinum, if it be sarcoma radiation offers hope, but if it is secondary carcinoma little or nothing can be accomplished.

A primary growth may be silent and give no symptoms while the metastases may give a variety of symptoms and may appear to be the primary trouble. This may occur with a variety of tumors, as for example, sarcoma of the testicle may give metastasis to the abdomen and the symptoms of this abdominal mass may dominate the picture. Similarly the metastases from a pigmented congenital mole may be various and inexplicable until a careful examination reveals the primary growth.

Metastases may supply the only symptoms or may confuse the picture of the primary growth. Pains in the lumbar region, or pain resembling sciatica may be due to metastasis to the spine from a tumor of the breast, thyroid, prostate or adrenal. The primary growth may be overlooked, or as in the case of a breast carcinoma the period since operation, without local recurrence, may be so long as to have given a false sense of security with a resulting failure to recognize the true cause of the pain. Cerebral symptoms with perhaps blindness, headache and even Menier's syndrome, may be due to a metastasis and the true nature of the case will not be diagnosed unless the primary growth is discovered. Herrick has reported a case in which he believes the picture of diabetes insipidus was the result of a cerebral metastasis from a mammary cancer.

Pulmonary metastases may result in a picture closely simulating pulmonary tuberculosis. Pleural effusion may be the first evidence of a mediastinal metastasis; hemothorax of metastasis to the pleura. Herrick describes how often the medical man is asked to cure a bronchitis prior to an operation for cancer of the tongue for example,

only to find that the so-called bronchitis is in fact the result of multiple pulmonary metastases.

Prognosis is, of course, seriously influenced by the discovery of metastasis but to a varying degree under different conditions. Metastasis to regional glands, if these can be excised, is of less grave import than metastasis at a distance. Enlargement of regional glands in a case of tumor does not always indicate that metastasis to the glands has occurred. This is often forgotten although Recamier as long ago as 1829 pointed out that such enlargement of lymph-nodes may be brought about by either irritation and inflammation or by extension of the cancerous process. He further describes how " the inflammatory nodes conserve their elasticity and decrease in size, while on the contrary, the cancerous nodes which are firm and irregular increase in size, after the removal of the diseased organ." This is of obvious importance in prognosis and treatment. Often the decision as to whether or not gastrectomy shall be attempted in a case of carcinoma of the stomach, rests upon the palpation of enlarged glands in the gastric mesentery. This must lead occasionally to fallacious conclusions, especially since the opportunity for the absorption of toxic matters is great in the case of ulcerating cancer of the stomach. It is the rule in the enlargement of the pelvic glands in cancer of the uterus and in the cervical glands in cancer of the tongue. Instances are on record where enlarged cervical glands were on one side inflammatory and on the other due to metastasis from a carcinoma of the tongue. Metastasis may at any time take place in such glands previously enlarged simply by inflammation.

Metastases to internal organs or to bone profoundly affect the prognosis, and multiple metastases from cancer of the internal organs to the skin are of equally serious significance. These are not very common, Suzuki in 1918 collecting but 110 reported cases. The majority were cases of adenocarcinoma or of medullary cancer of the digestive organs; the metastases occur in both cutis and subcutis and are most frequent over the thorax and abdomen. Such patients rarely survive more than three months after the appearance of the cutaneous metastases. On the other hand lymph-node metastases sometimes remain stationary in size for a considerable period.

Not only is prognosis seriously influenced by the discovery of

metastases, but as has been mentioned before, one's decision as to treatment is very much affected. There is usually little justification in attempting a serious operation for removal of the primary growth in the presence of recognized and irremovable metastases. Of course, operation may be indicated even in the presence of metastases, perhaps to give comfort, perhaps to prolong life, but it should be done knowingly. It is usually useless to amputate the breast for carcinoma when secondary deposits in bone have developed; it would be more reasonable to perform a cordotomy for the relief of pain produced by the metastasis. No case of tumor should be operated upon before a careful and intelligent search for metastases has been made; X-ray studies of the lungs and bones may be required to reveal silent metastases. There is no evidence to justify the hope that there will occur a regression of the metastasis once the primary growth is removed. Permanent regression of a tumor in man has occurred perhaps two hundred times in the past fifty years according to Woglom, but not as a result of a removal of one unit of a disseminated process.

The same line of reasoning applied to operation is also true, but to a less extent, in connection with radiation. There is little to be hoped for from radiation of a primary growth which has given distant metastases and unfortunately metastases are apt to be too numerous and too unfavorably placed for successful local treatment with X-ray or radium. Furthermore, metastases may be less amenable to treatment.

In speaking of treatment it should be stated that operative manipulation of a tumor may be the means of spreading metastases, but with modern surgical technic this has become rare. Efforts to rub away a neoplastic growth are still prolific sources of metastasis. Radiation apparently has no tendency to promote metastasis.

Much more might be said concerning the clinical aspects of metastasis but this brief statement will suffice to show how varied is the interest of the clinician, both medical and surgical, from the point of view of both diagnosis, prognosis and treatment in this subject.

To-day the term metastasis is still employed in a number of different connections, with a varying significance, and without connoting anything as to nature of the material transferred, the means

of transport, or the factors determining the secondary location.　The term does imply a distinct transfer but has ceased to be associated with any thought that the appearance of the secondary phenomenon results in a disappearance of the primary.　The term " crisis " we still have, but coction and metastasis, in this sense, have disappeared from use.　No longer do we speak of milk or bile metastasis, but metastatic mumps, metastatic iritis, calcium metastasis, metastatic abscesses and neoplastic metastasis are in frequent use.

In these several examples of our use of the term metastasis we have seen that it is applied to the transfer of a filterable virus, of bacteria and perhaps of their toxic products, of tumor cells and of an inorganic element.　In these several types the factors determining the sites of localization have also varied and have included those governing simple embolism, tissue predilection and local chemical states.　In the final analysis we find that to-day we know little more than when in 1663 Boyle wrote of " what not infrequently happens in distempered bodies by the metastasis of the morbifique matter."

Industrial Medicine

HEALTH AND HYGIENE IN INDUSTRY

A TALK FOR THE RECENT MEDICAL GRADUATE, ON THE
SIMPLE, EVERYDAY CAUSES OF DISEASE IN INDUSTRY

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HEALTH in industry is dependent, as it is in any other condition in life, on the proper care of the human body. In industry, however, in addition to the desire of all men to feel well the worker has continually before him the necessity to be well in order to continue to be able to work; and the employer, in addition to his kindly interest in the welfare of his workers, has found by his own experience and that of others that the prosperity of his business is to a very great extent dependent on the good health of his employees.

There is a great deal of unnecessary illness in the United States. The National Conservation Commission, appointed by Roosevelt in 1909, found that there are at all times in this country approximately 3,000,000 seriously ill people. This means an average loss through illness of thirteen days for every person in the course of a single year. In addition, the Commission stated that 42 per cent. of this illness could be prevented. My personal opinion is that this figure should be 50 per cent.

Such figures as these carry their appeal to the young medical graduate who is planning to specialize in industrial medicine, for they show him that here is a field in which his earnest efforts may be well rewarded. He need mention them merely in order to convey a strong impression to employers and employees both of the importance of obeying hygienic laws and of having recurrent physical examinations which will aid him vastly in his work.

We talk so much about industrial diseases but personally I believe these are few. Inhalation of stone and steel, inorganic dust, and the

absorption of lead and phosphorus, and in oil industries the irritation of the skin from preparations of tar are of course deleterious, but the diseases attributed to them are frequently due to unhygienic conditions. Examining into the cause of the great prevalence of tuberculosis among the workers in a nail factory, I recently found the disease was not due to the nature of the work at all but to the fact that the workmen lived in old, antiquated, damp houses that had been built with too few windows on account of the cold climate and tuberculous people had been living in them for years. You will find that many of the diseases attributed to industry are the diseases that anyone may get in any walk of life or in any kind of work.

Care of the human body and personal hygiene are not essentials confined to industry alone but they are the foundation of industrial medicine. Lead and phosphorus may be said to be purely industrial problems, but the sufferers from these poisons are few compared with the great mass of industrial workers. Ill health among them, barring accidents and the incidence of real industrial diseases, occurs largely through their own ignorance of the proper care of their bodies and the lack of adequate facilities at the plant and in their homes to maintain this proper care, during their hours of toil and afterward.

Employers and employees should be instructed that one of the great essentials to the maintenance of good health in the worker is represented by his drinking water. It is not so much a question of the purity of the supply, for most industries are located in or near cities and the purity of the water is maintained by the city. The important questions are, does a man drink sufficient water; is there an adequate supply near his work-bench; is it of the proper temperature, being neither iced nor tepid; is it attractive in that it comes bubbling from a fountain, sparkling and enticing and cool, or is it inert and insipid? Sufficient water must be drunk, for the body loses about five pints every day and this must be resupplied or the workman will become inefficient. Water increases all the secretions, it is nature's greatest solvent, and it increases peristalsis. Teach the workman the value of these three functions and he will increase his drinking of water. He should know that the effect of water increases the saliva and saliva is necessary for moisture of the mouth and for digestion; increasing the gastric juice increases it in quantity and

in strength; that it improves all the organs that make secretions, the pancreas, thus aiding digestion; the kidneys, thus aiding excretion; the mucous membranes, thus aiding the fulness of the blood-vessels and the elimination of waste. Moisture must be supplied to the lungs, the lining of the joints, the covering of the tendons and the intestines, the brain and the spinal cord. Drinking water helps to get rid of waste products, and this, *it should be pointed out,* is of great importance in industry, for waste products are one of the prime causes of fatigue. Drinking water helps to get rid of the heat manufactured in the body under the strain of active exercise during labor and which must be gotten rid of or it will tend to lower the vitality of the worker. The loss of heat takes place through the lungs and skin and plenty of water aids the action of these organs and helps to keep the temperature normal.

Keep in mind that although there is no more simple rule of health, the drinking of sufficient, pure, cool water is one of the most important necessities in the warding off of illness, particularly among workers.

The next problem that confronts the advocate of hygienic living for the working man is the necessity for securing proper places for him to excrete his water. This is not so much a question of toilet and baths but of the existence of sufficient urinals and their location near his place of work. There should be more urinals than there are toilets in large industrial plants. The habit of suppressing the urine, which may easily be acquired if too long a time is required from work to seek relief, is a bad one. Then, too, urinals do not, like toilets, offer a place in which to loaf and waste time.

It is, of course, just as important that there be adequate toilets. Many workmen leave home too soon after breakfast in the morning to have been able to secure a movement of the bowels, which of course should take place daily as an absolute essential to health. Employers should have the importance impressed upon them of the necessity for a sufficient number of toilets for all the workmen. The old privy vault, with its odors and soiled seats, is disappearing, and it should entirely disappear. There should be first-class toilets and they must be kept clean and without odor. Fatigue is often dependent upon the

absorption of toxins from the intestinal tract and toxins are generated by retained accretions in the bowels.

It is not the province of this lecture to discuss the various diseases to which man is heir, or the physiological processes of the body, so the conditions to which fatigue gives rise and the manner in which this occurs will not take up our attention at this time, particularly since these facts are well grounded in the minds of the neophyte who is just beginning his life work in medicine. But the importance of avoiding overfatigue in industry cannot be overestimated and the specialist in industrial medicine will do well to bear this in mind. A worker who delays having a movement of the bowels absorbs a large amount of toxins, particularly indol, which reduces muscular efficiency to a very marked degree. Then, too, the psychological effect of fatigue with its power to reduce the desire for work is too apparent to everyone to need emphasis here. A tired man is also very much more subject to disease, especially contagious disease, for his resistance is decreased; his opsonic index is lowered. The sweep of an epidemic, apparently magically mowing down group after group of workers, and equally magically and apparently unreasonably sparing an odd man here and there, will some day be an impossible occurrence, for increasing knowledge of the causes for longevity and the ability to resist disease is slowly bringing more effective prophylaxis into the field of medicine in general and, of necessity, into the field of industrial medicine.

In the efficiency of the worker much depends on the air he breathes and the food he eats.

Fresh air! Who is there among the laity in these days, to say nothing of those of the medical fraternity, that can sufficiently emphasize its value to life itself? And yet how seldom within doors does one breathe really fresh, pure air, particularly in an industrial plant. It is the rule, of late, rather than the exception, in large factories to find an attempt has been made, frequently successfully, to provide proper ventilation. Where the exception prevails, it must be corrected as soon as possible. Free circulation of air, particularly in crowded workrooms, is absolutely necessary to efficiency. It is also one of the greatest aids in the prevention of epidemic diseases. Energy is dependent on sufficient oxygen and absence of carbonic acid gas, and

on the maintenance of normal body temperature. These things are well known. Also is it well known that in the air about many industries by the nature of their products there are gases, the breathing of which if long maintained is deleterious to health. The value of providing proper ventilation and the elimination of gases from the air circulated about the workrooms is so well recognized that it need not be dwelt on in this lecture, the purpose of which is to confine attention to the simple, everyday causes that lead to bringing about and keeping the workman in the average industrial plant in good health.

One of these simple causes is the absence of dust. Not any special kind of dust—*all* dust. Volumes have been written on the harmfulness of dust, as a generic whole or as a specific breeder of disease such as anaphylactic conditions, disease of the lungs, disease of the eyes, and so on. And yet dust continues to be a menace. All dust should be removed with proper cleaning implements and this cleaning process should be repeated daily, weekly, monthly, yearly. Dust should never be allowed to lie or fly about in rooms where men are gathered for work and they should be taught to themselves regard it for the menace that it is. No dust is allowed to lie about valuable machinery, for the owners well know its possibilities for harm. Should not the human machine be as equally well protected? Otherwise, wearing out will be the inevitable result.

A most important, and not so simple, rule of health is the eating of proper food. Of course, individuals and races differ in their food likes and dislikes, to say nothing of their ability to get the best results from staple foods. There are idiosyncracies against absolutely necessary foods, but this would form a chapter in itself and is a subject entirely familiar to the young physician. That all people should eat properly selected, well-balanced foods is an axiom so familiar to everyone that it paradoxically becomes unfamiliar through being ignored. The workingman's lunch should not be the cursory affair it generally is; a snack put up by the wife and composed of left-overs or hastily bought delicatessen provender. It should be an attractive meal having sufficient calories, carbohydrates, and vitamins and it should be easily digestible, and it should have variety from day to day. It should be chosen with a consideration of weather conditions

and it should be eaten in a place that is comfortable and attractive. The physiological effects of food are too often dependent on psychological reactions for this to be overlooked by the man who has the responsibility for the bodily welfare of a number of working men on his shoulders, and he should not be above prying into the dinner pail, or superintending the menus of the workman's lunchroom, and suggesting whatever occurs to him as conducive to the purpose he has in view. In addition he should offer suggestions to the men themselves, as occasion arises, regarding the food they take while not at the works, food that will build up muscle and tissue, and fat; that will supply real fuel; that will contain the proper salts, minerals, and vitamins; those that will supply fluids; and those that have sufficient bulk. Point out to them the great importance of a proper regulation of the diet and that bodily activity, growth and even length of life depend largely upon the character of the food they eat. Be specific; chart diets for them. The industrial physician who secures the confidence of the workmen of the plant that employs them both will have an infinite power for good; he will also be a happy and contented man, feeling that life is well worthwhile.

One of the simple causes of inefficiency at work is lack of proper sleep. Educating the workmen who look to you for guidance in keeping well in matters of food, drink, body excretions and breathing pure air should be further pursued in advising him how necessary is the proper amount of sleep every twenty-four hours. The avoidance of fatigue during the working hours depends to a very large extent on the amount of sleep the man has had the night before. As a rule he must get up early to go to work, and if he has had a belated evening of pleasure the night before he will attribute his reluctance to rise to the right cause. But he will not, without having it brought to his attention, attribute illness that attacks him, eye-strain that annoys him, unusual discomfort from cold and dampness that surprises him, to his having had insufficient sleep. It will doubtless be news to him that sleep is more necessary to him than food, but he will realize it when he learns that animals deprived of food may live more than three weeks, but deprived of sleep they live only three or four days. There would be less illness among working men if they all slept suffi-

ciently. They should also give more consideration to the matter of bedclothes, the bed itself, the bedroom and its ventilation. The bed should be kept clean and should be made of material to facilitate this. Single beds are advisable though not always possible. The window should be kept open during sleep and the bedclothes depended upon to keep warm. The workman should understand that these directions are for his guidance when well and able to secure normal sleep at an habitual time for retiring. If he is unable to sleep without his being able to assign and remove the cause, emphasis must be placed on the importance of his consulting you on the subject which is not a matter of indifference as he might otherwise think. The abnormal causes for his lack of being able to sleep you will undoubtedly soon be able to discover, though they may escape his attention in spite of their being very simple. Cold feet, worry, hunger, indigestion, overeating, improper covering or overfatigue may be responsible. If there is pain, fever or illness, sleep may of course be impossible, but that is a different story. The posture in which he goes to sleep may be preventing a proper circulation of the blood through an arm or leg, or the head may be too high or too low on the pillow. Eye-strain from watching motion pictures may be the cause. It may prove a consolation to reflect that the hard-working man seldom suffers from insomnia, but that it may occur should not be overlooked in the consideration of these simple and everyday causes of ill health. And the insomnia which comes from these simple causes fortunately does not require treatment by narcotics. It is one of the most gratifying achievements in medicine to find and remove the cause of a condition, and this being the end and aim of every true member of the medical fraternity, he will find it a great source of satisfaction to live and work among laborers.

The average working man regards the act of washing his hands as a matter of no importance. If they are very soiled from his work he will wash them before going home at night, or as soon as he arrives there. He may or may not wash them before eating his lunch. Left to himself, it is doubtful if he ever washes them during the day. The importance of keeping the hands as clean as possible should be impressed upon him, primarily because disease may be conveyed into

the system through dirty hands. He should wash his hands after going to the toilet and before eating, and facilities, readily accessible, should be furnished for this purpose. He should scrub them with a brush, warm water and soap and dry them on a clean, coarse towel. From the employer's point of view, washing of the hands is of importance in connection with the workmen's compensation laws. A large percentage of accidents consist in slight wounds to the hands which, if dirty, may lead to infection and poisoning; tendons may be destroyed, joints become stiff, nerves ruined, and hands and fingers twisted and deformed. In this way, hands that have been trained for years in a trade may be rendered useless through infection merely from dirt being left on them too long.

It may not be easy to educate the working man up to the proper standard in the matter of bathing. That he takes a bath every Saturday night makes him in his own eyes and those of his associates a man of cleanly habits. On this point he may resent any suggestion as being an insinuation. Consequently it will have to be with the utmost tact that this is handled. The reasons for bathing are those for washing the hands. A skin that has recently been bathed and is reasonably free from bacteria is less liable to suffer ill effects from an abrasion or other accident; a skin that has recently been bathed does not give off offensive odors of dirt and perspiration; a skin that has recently been bathed is less liable to disease of the skin itself, and this is particularly true when the disease is due to lice. Last of all, a skin that is kept clean will readily assist the body to get rid of waste products which come out through the pores. Then, too, a clean skin helps to keep the body cool in summer.

There are many other simple matters pertaining to the maintenance of good health, such as proper exercise, abundance of sunshine, proper clothing, care of the hair, eyes, mouth and teeth, ear, nose, and throat, the avoidance of insect bites, freedom from worry and anger and anxiety. There are individual problems to be considered and much misunderstanding to clear away.

This whole talk has been devoted to everyday matters of hygiene, so simple that although their value is well known it is frequently obscured by considerations of physiological processes, etiological conditions much further afield, and expensive safeguards against acci-

dents and the diseases peculiar to industry. These things are of course important; they form the foundation of the industrial physician's work and it is his constant study of them that makes him worthy of his great trust. Underlying all his work, however, is the necessity for gaining the confidence of his charges. Even if he is caring for the health of a thousand men he should regard each one as an individual exactly as he would each patient in private practice who had come to him of his own volition. Of all his qualities, the most important is personality; make each of these men feel that it is his interests and his alone that inspires your advice to him and your demands on him and he will soon coöperate with you and help to bring about your success in the life work you have chosen.

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